BRUSH

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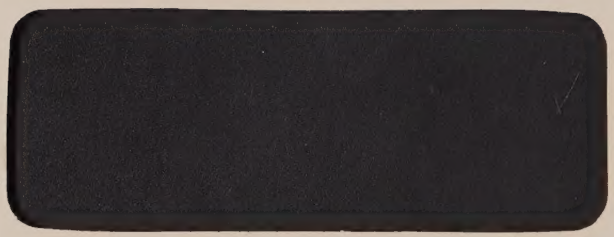
OPERATING INSTRUCTIONS



MANUAL PART NO.
15-806327-50

MARK 220 RECORDER

INSTRUMENT SHOP

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CLEVITE
CORPORATION
brush INSTRUMENTS DIVISION / 37TH AND PERKINS / CLEVELAND, OHIO 44114

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Section I
General Information

1.1 INTRODUCTION

The Brush Mark 220 Recorder (Fig. 1-1) is a completely self-contained, portable, lightweight two-channel analog recorder.

The recorder features a pen-position servo system, based on a frictionless transducer, assuring extreme accuracy. The writing system employs pressurized ink contained in a disposable plastic cartridge which can be replaced in minutes. Pen motion is rectilinear.

Recording range extends from one millivolt to 500 volts A.C. peak-to-peak and one millivolt to ±250 volts D.C. Input is differential balanced-to-ground, or single-ended by use of ground strap. Frequency response is flat from D.C. to 100 cps at ten divisions, with full scale response at 40 cps (±2% full scale).

Full functional control, including 13-step attenuation, intermediate sensitivity, and pen positioning is provided on the front panel for each analog channel. Adjustable electronic pen limiters on amplifier prevent analog pen damage from off-scale signals. Two event markers are standard on left and right-hand margins. A third event marker may be added between analog channels. Convenient jacks on rear panel permit activation of markers from an external switch closure.

Four chart-speeds of 1, 5, 25 and 125 millimeters per second are electrically selected by pushbuttons. Chart tracking error is less than 0.025 of an inch in 10 feet after stabilization at high speed. Chart capacity is 275 feet with high-contrast Kromekote and 400 feet with reproducible paper.

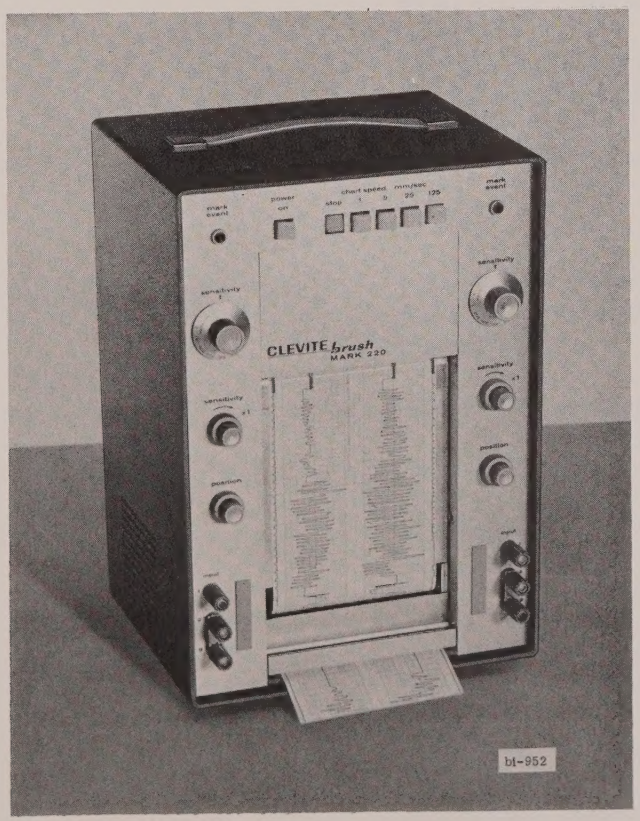


Figure 1-1 Brush Mark 220 Recorder

1.2 SPECIFICATIONS

This paragraph lists the specifications and data pertinent to the Mark 220 Recorder.

a. General

Number of Channels	2 Analog, 2 Event
Channel Width	40 mm, 50 divisions per channel
Trace Presentation	Rectilinear
Trace Width	0.01 inch nominal
Writing Method	Pressurized fluid (U.S. Patent 3,054,109)
Writing Fluid Capacity	1 oz; sufficient for one year of normal recording
Chart Description	4.3 inches wide--two 40mm grids graduated in 50 divisions across span. Graduated 5mm increments on time axis. Right and left event marker channels
Chart Capacity	275 feet - high contrast 400 feet-reproducible
Chart Speeds	1, 5, 25, 125 millimeters per second and STOP
Chart Speed Accuracy	±0.25%
Operating Temperature	0 to + 55°C. Recorder will remain within specification over range of ±10°C from temperature at calibration
Storage Temperature	-40° to ±85° centigrade
Principle Dimensions	Refer to Figure 1-2
Weight	25 pounds

b. Electrical

Measurement Range	1 millivolt per chart division to 500 volts D.C. full scale (50 chart divisions)
Input Circuit	Differential, balanced-to-ground
Input Impedance	10 megohms balanced, 5 megohms each terminal to ground

NOTE: ALL DIMENSIONS ARE
IN INCHES

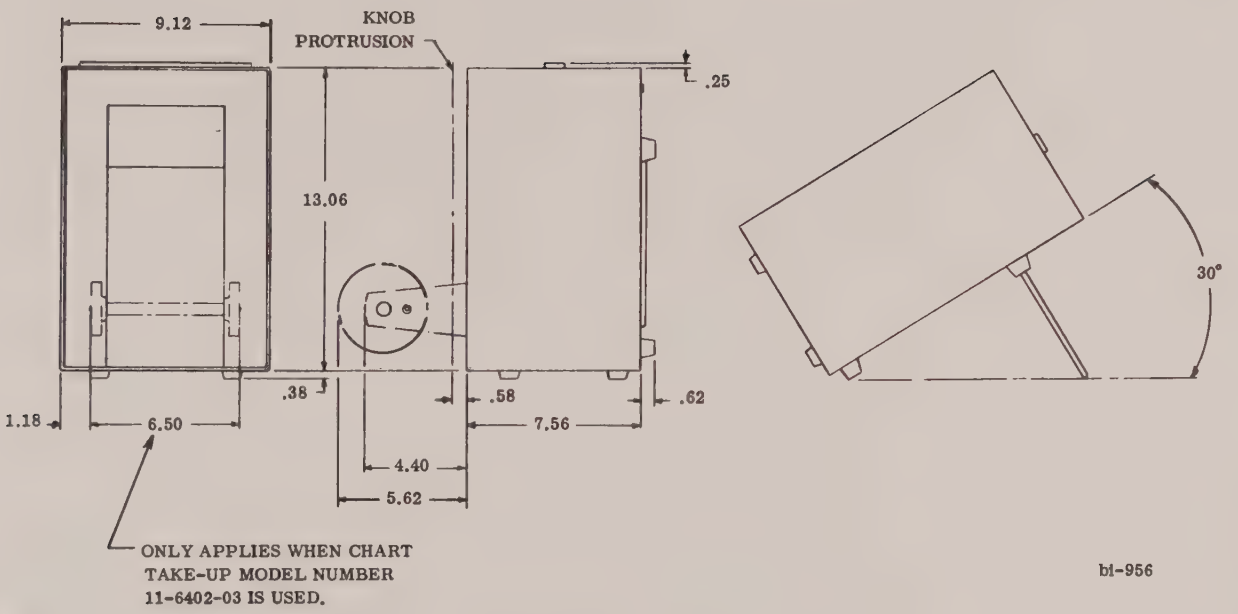


Figure 1-2 Mark 220 Outline Dimensions

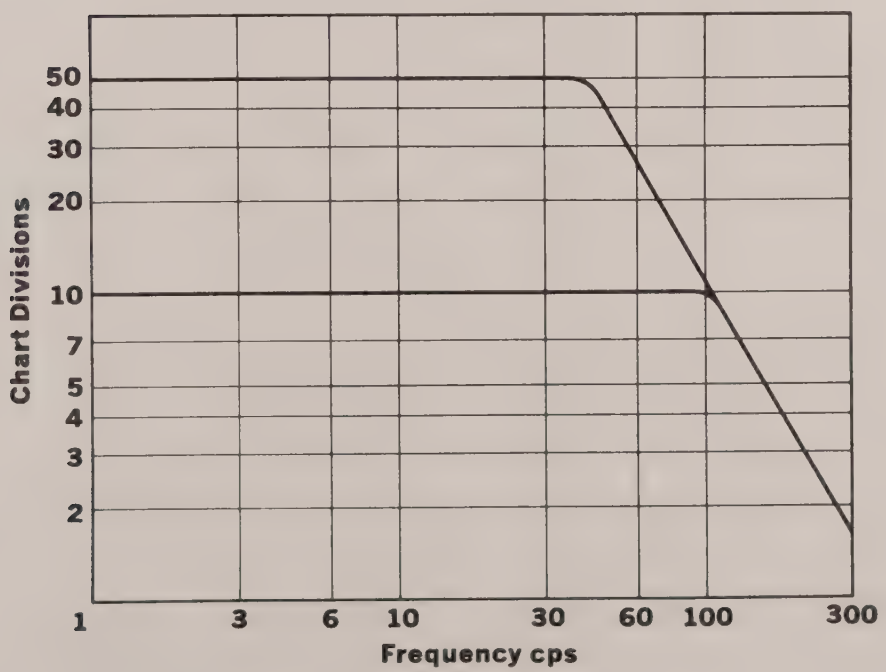


Figure 1-3 Frequency Response Curve

1.3 SUPPLIES AND ACCESSORIES

a. Supplies

Chart Paper

High-Contrast, Kromekote (275 feet)	11-2923-31
Reproducible (400 feet)	11-2923-43
Analog Pen	11-2823-33
Event Marker Pen	11-2873-20
Band Replacement Tool	341409-915

b. Accessories

Starter Kit	11-6250-00
Consists of:	
Chart Paper (12 rolls)	11-2923-31
Gram Gage	240601-910
Pen Pressure Wrench	1-120922-18
Pen Replacement Wrench	1-120922-2
Dust Cover	465971
Replacement Kit	11-6251-00
Consists of:	
Chart Paper (12 rolls)	11-2923-31
Analog Pens (2)	11-2823-33
Event Marker Pens (2)	11-2873-20
Ink Cartridge (1 oz)	11-2730-01
Rack Mounting Kit	11-1202-08
Internal One-Second Timer	11-6101-21
Chart Takeup	11-6402-03
Interchannel Event Marker Kit	11-6221-00

Section II
Installation

2.1 GENERAL

This section describes the inspection checks to be performed upon receipt of the Mark 220 and details power requirements and signal connections. In addition, this section describes and illustrates installation of the Chart Takeup, Interchannel Event Marker, One-Second Timer, and Rack Mounting Kit.

2.2 INCOMING INSPECTION

Perform the following procedures before operating the recorder.

1. Visually inspect unit for damage that may have occurred during shipment. Refer to warranty sheet in case of damage.

2. Remove packing material and tape from recorder.

2.3 POWER REQUIREMENTS

Connect power cable (P-301) to correct power source listed below for that particular model.

Model No.	Power Source
15-6327-50	115 volts A.C. ±10%; 60 cps, 120 watts
15-6327-55	115 volts A.C. ±10%; 50 cps, 120 watts
15-6327-56	230 volts A.C. ±10%; 50 cps, 120 watts

2.4 SIGNAL CONNECTIONS

a. Drive Amplifier Input Signal

Connect signal to INPUT 1 and 2 terminals on front panel. For single-ended input, connect ground strap to terminal 2. For balanced or double-ended input, disconnect ground strap.

NOTE: A positive input to pin 1 will cause the pen to deflect to the left.

b. Event Marker Signals

The event markers are actuated by pushbutton switches located on front panel. The left marker pen deflects to the left, right marker pen deflects to the right. Event markers may also be actuated by external switch closure (short) across terminals located on rear panel.

NOTE: Resistance of each event marker coil is 600 ohms and has -32 volts D.C. connected from an internal source.

2.5 CHART TAKEUP INSTALLATION (MODEL 11-6402-03)

Refer to Figure 2-1 and perform the following:

1. Disconnect recorder from power source.

2. Remove recorder from case, (refer to Para. 4.3a).

3. Remove plastic caps covering slots in front panel.

4. Remove ground straps from channel input terminals and set aside.

5. Remove screw and remove shield can from rear of channel 1 input terminals.

6. Loosen nut, on rear of middle binding post on channel 1 input terminals, allowing shield can mounting bracket to rotate free on binding post.

7. Position chart takeup on front panel with drive belt on left side.

8. Attach chart takeup to front panel with four screws and four lockwashers.

9. Slide pulley onto pressure roller shaft and secure with cotter pin.

10. Position chart takeup drive belt around pulley.

11. Position shield can mounting bracket and tighten nut on middle binding post.

12. Attach shield can to mounting bracket at rear of channel 1 input terminals with screw.

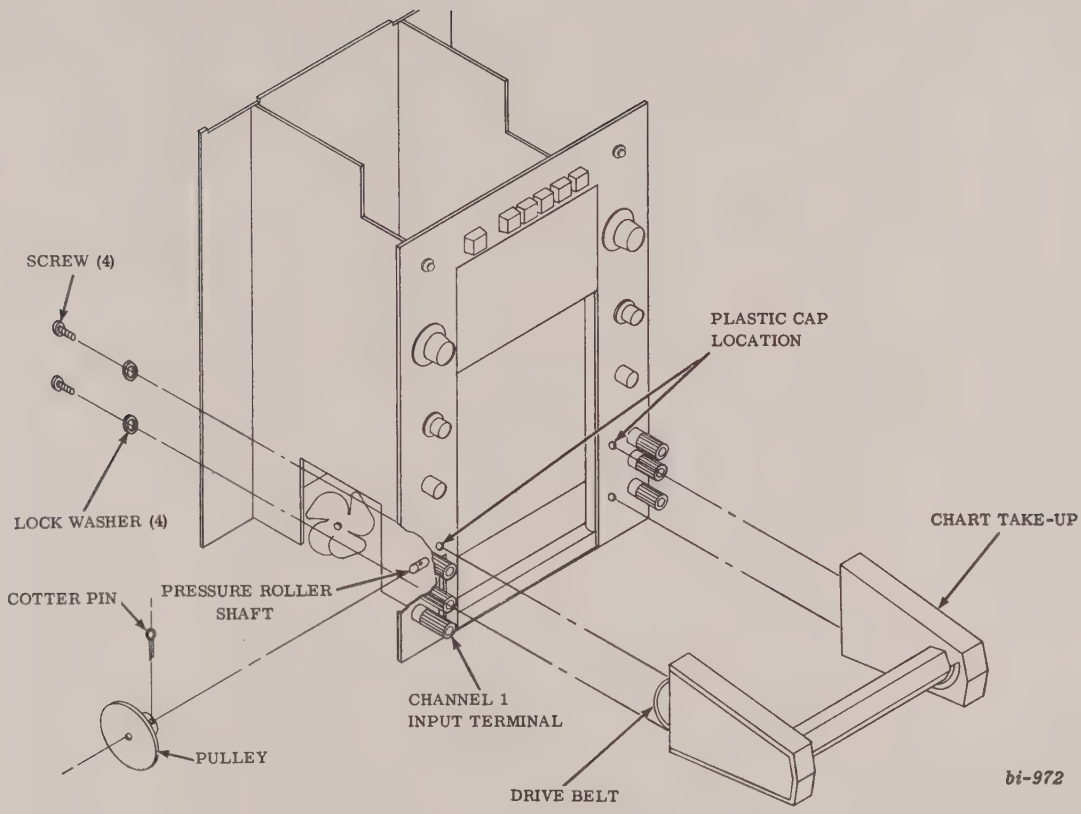


Figure 2-1 Installation of Chart Takeup, Model 11-6402-03

13. Replace ground strap.

NOTE: The ground strap should be positioned so that when disconnected from middle binding post it will swing away from chart takeup.

14. Install recorder in case (refer to Para. 4.3b).

2.6 INTERCHANNEL EVENT MARKER INSTALLATION (MODEL 11-6221-00)

Refer to Figures 2-2 and 4-5 and perform the following:

1. Disconnect recorder from power source.
2. Remove recorder from case (refer to Para. 4.3).
3. Remove pen access cover.
4. Secure Event Marker to penmotor mounting bar with self-tapping screws.
5. Connect black lead from Event Marker to terminal 2 and blue lead to terminal 3 of terminal board, TB-302, at rear of recorder.
6. Install jacks into existing holes in rear panel.
7. Attach capacitor across jacks (do NOT solder).
8. Solder one end of 10-inch lead to one end of capacitor and jack as shown.
9. Connect other end of 10-inch lead to terminal 3 of terminal board TB-302.
10. Solder one end of 4-inch lead to capacitor and jack as shown.
11. Solder other end of 4-inch lead to existing jack as shown.

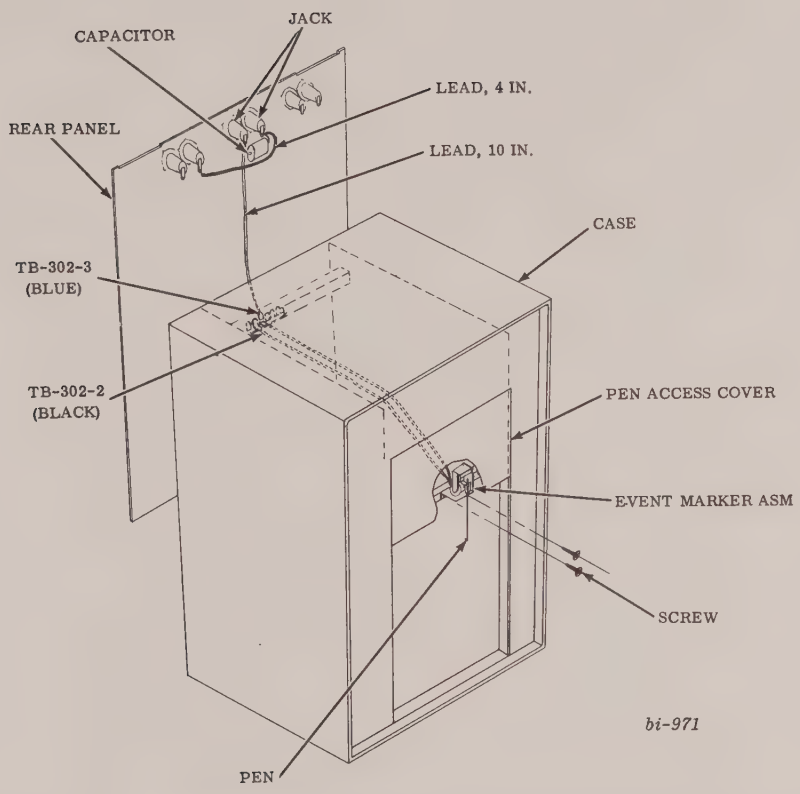


Figure 2-2 Installation of Interchannel Event Marker, Model 11-6221-00

12. Install pen on Event Marker (refer to Para. 4.5).

13. Remove cap from manifold nipple and connect ink tubing from pen to ink manifold nipple.

14. Turn ink valve control clockwise to ON position.

15. Check and adjust pen pressure (Para. 4.7 and 4.8).

16. Lap pen if required (Para. 4.9).

17. Install recorder in case.

18. Replace pen access cover.

2.7 ONE-SECOND TIMER INSTALLATION (MODEL 11-6101-21)

Refer to Figure 2-3 and perform the following:

1. Disconnect recorder from power source.

2. Remove recorder from case (refer to Para. 4.3).

3. Remove four screws securing rear panel to recorder and move panel to one side to allow access to inside of rear panel.

CAUTION: Use care when moving rear panel so not to break attaching leads.

4. Relieve pressure on ink cartridge (refer to Para. 4.10, step 3).

NOTE: Relieving pressure on cartridge will prevent ink escaping if tubing is accidently pulled from cartridge.

5. Position timer on inside of rear panel and attach with two screws.

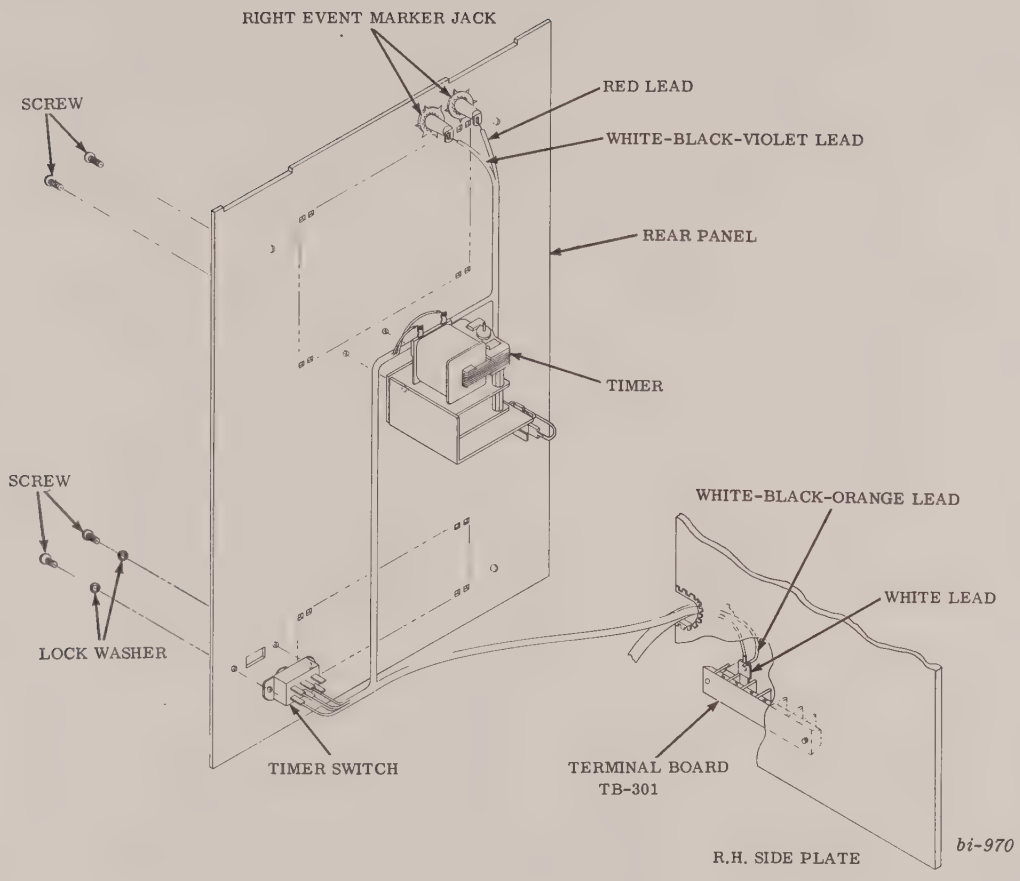


Figure 2-3 Installation of One-Second Timer, Model 11-6101-21

6. Position timer ON-OFF switch on lower right-hand corner of rear panel and attach with two screws and two lock washers.

7. Solder red and white/black/violet leads to right event marker jacks.

8. Connect white lead to terminal 5 and white/black/orange lead to terminal 6 on terminal board TB-301 on the right-hand side plate.

9. Apply pressure to ink cartridge (refer to Para. 4.10, step 4).

10. Position rear panel on rear of recorder and secure with four screws.

11. Install recorder in case.

2.8 RACK MOUNTING INSTALLATION

The Mark 220 Recorder may be rack mounted in a standard 19-inch RETMA cabinet using Rack Mounting Kit, Model 11-1202-08.

a. Installation

Refer to Figure 2-4 and perform the following:

1. Remove four screw and rubber feet from bottom of recorder.

2. Attach support bracket to bottom of recorder with four screws and lock washers.

3. Attach two bottom nut bars to cabinet front rails at desired height using two screws and spacers.

4. Position right-hand hanger behind nut bar and attach to front rail with two screws.

5. Position support hanger against rear rail and attach with two screws.

6. Align slotted holes on hanger with holes on support and install two screws.

7. Perform steps 4, 5, and 6 to mount left-hand hanger.

NOTE: The above procedure is used when the rear mounting is a single-bend cabinet rail. If the rear mounting is a multiple bend cabinet rail, the support hanger is not required. Instead, slide two floating nuts, onto the rear rail, position hanger against rail, and attach with two screws as shown on left rear rail in Figure 2-4.

8. Attach two top nut bars to cabinet front rails using four screws and spacer.

9. Slide support bracket with recorder attached onto hangers.

10. Position front panel around recorder and attach to front rails with four screws, nylon washers, and countersunk washers.

b. Removal

1. Remove four screws and attaching hardware and remove front panel.

2. Remove four screws and lock washers from support bracket and remove recorder.

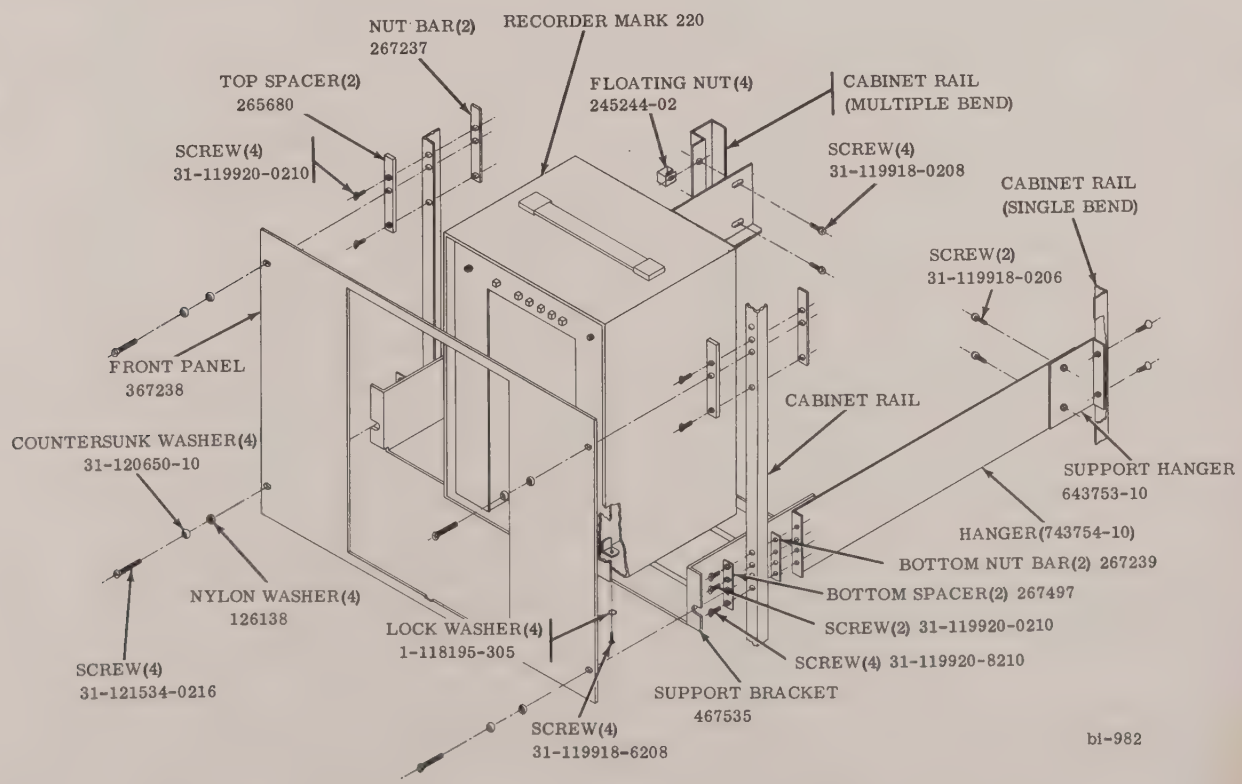


Figure 2-4 Installation of Rack Mounting Kit, Model 11-1202-08

Section III
Operation

3.1 GENERAL

This section describes and illustrates the controls on the Mark 220 Recorder and also provides instructions for proper operation.

3.2 FRONT PANEL CONTROLS

NOTE: Item numbers listed below correspond to circled numbers in Figure 3-1.

Item No.	Control	Description
(1)	Power Switch	Controls A.C. power to recorder. Depress button to turn recorder ON or OFF. An internal lamp illuminates the pushbutton when the recorder is on.
(2)	Chart Speed Switch	Permits selection of the four chart speeds and STOP. When in STOP position chart drive is off, and pens will not respond to input signals. Depressing any chart speed button will activate the chart drive at the selected speed. Chart speeds may be changed while chart drive is running.
(3)	Mark Event Switch	Two momentary switches permit manual marking of an event. When left MARK EVENT button is depressed the left event marker pen will deflect to the left. When the right MARK EVENT button is depressed the right event marker pen will deflect to the right. NOTE: The event marker pens will remain deflected until the MARK EVENT button is released.
(4)	Sensitivity Control	Provides 13-step attenuation of input signal from one millivolt per division to ten volts per division, and OFF.
(5)	Sensitivity x1 Control	Provides intermediate sensitivities between the fixed settings of the stepped sensitivity control. When in the full clockwise x1 (detent) position, the sensitivity is fixed as indicated on the stepped sensitivity control. When rotated counterclockwise, the sensitivity is less than indicated on the stepped sensitivity control to a maximum ratio of 2.5 to 1. This control is fitted with a locking nut to prevent inadvertent turning. NOTE: This is a variable control, but not calibrated.

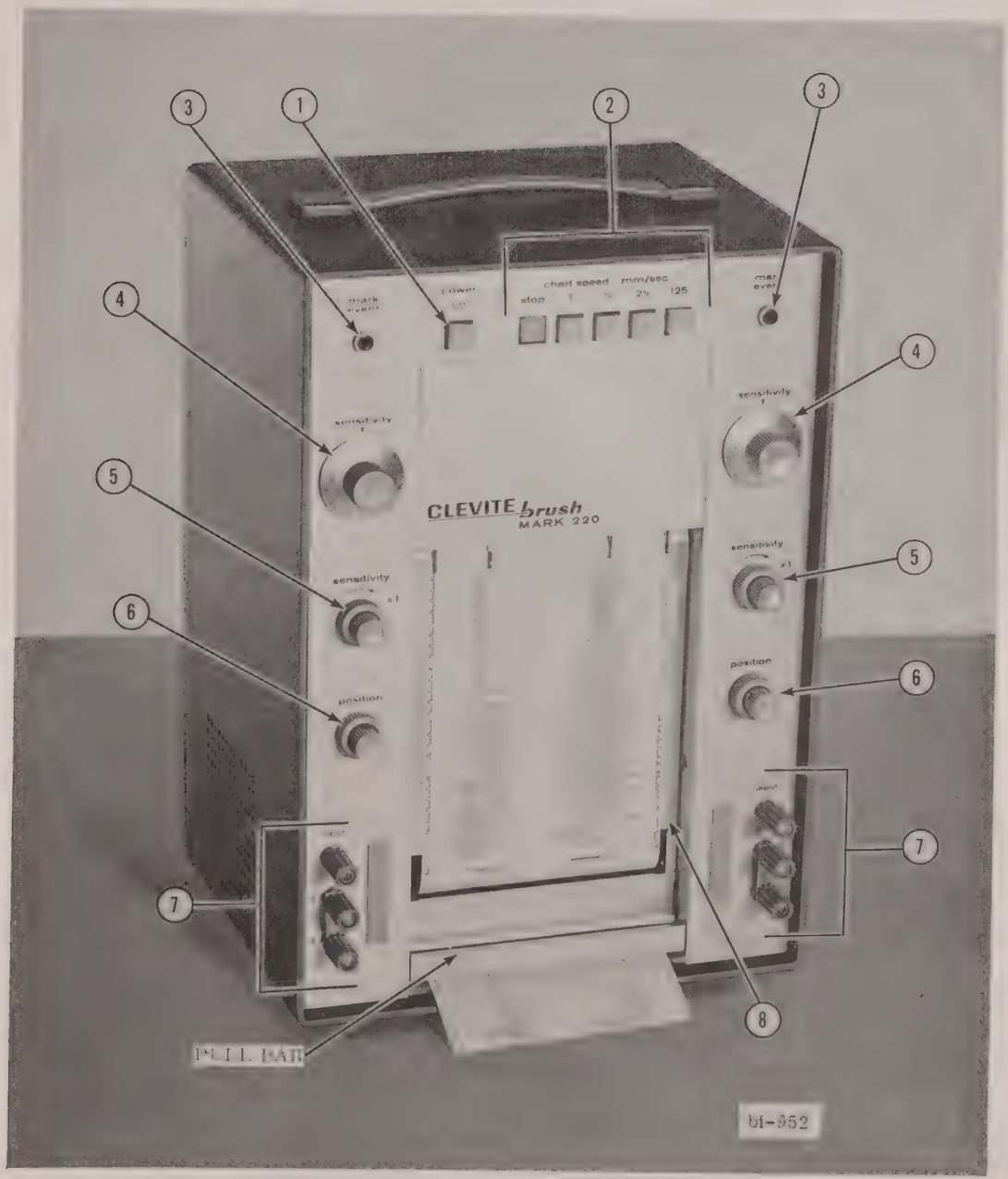


Figure 3-1 Mark 220 Recorder - Front Panel Controls

(6)	Position Control	Permits pen positioning anywhere within the channel and allows either edge of channel, or any point between to be used as zero signal position. This control is fitted with a locking nut to prevent inadvertent turning.
(7)	Signal Input Terminals	Three input terminals are provided for each channel. Ground strap is removable to provide balanced or double-ended input. Input is single-ended with ground strap connected.
(8)	Writing Table	Complete assembly consisting of table, writing bar and paper supply shaft. To gain access to the paper supply, pull out on pull bar and swing table up. To close, swing table down into position and push on pull bar until table snaps in place. NOTE: Writing table must be completely closed or recorder will not operate. Recorder is equipped with an interlock circuit which prevents operation when writing table is not properly closed or when paper supply is exhausted.

3.3 REAR PANEL CONTROLS

NOTE: Item numbers listed below correspond to circled numbers in Figure 3-2.

Item No.	Control	Description
(1)	Event Marker Right	Two jacks which permit actuation of right event marker by external switch closure. Placing a short between these two jacks will deflect right event marker pen to right (refer to Para. 2.4b). Pen will remain deflected until short is removed.
(2)	Center Event Marker Input (optional)	Two jacks which permit actuation of center event marker from external switch closure.
(3)	Event Marker Left	Two jacks which permit actuation of left event marker from an external switch closure. Placing a short between these two jacks will deflect the left event marker pen to the left (refer to Para. 2.4b). Pen will remain deflected until short is removed.
(4)	Tilt Support	Permits operation of recorder in 30 degree reclined position. Bar swings out and snaps in place.

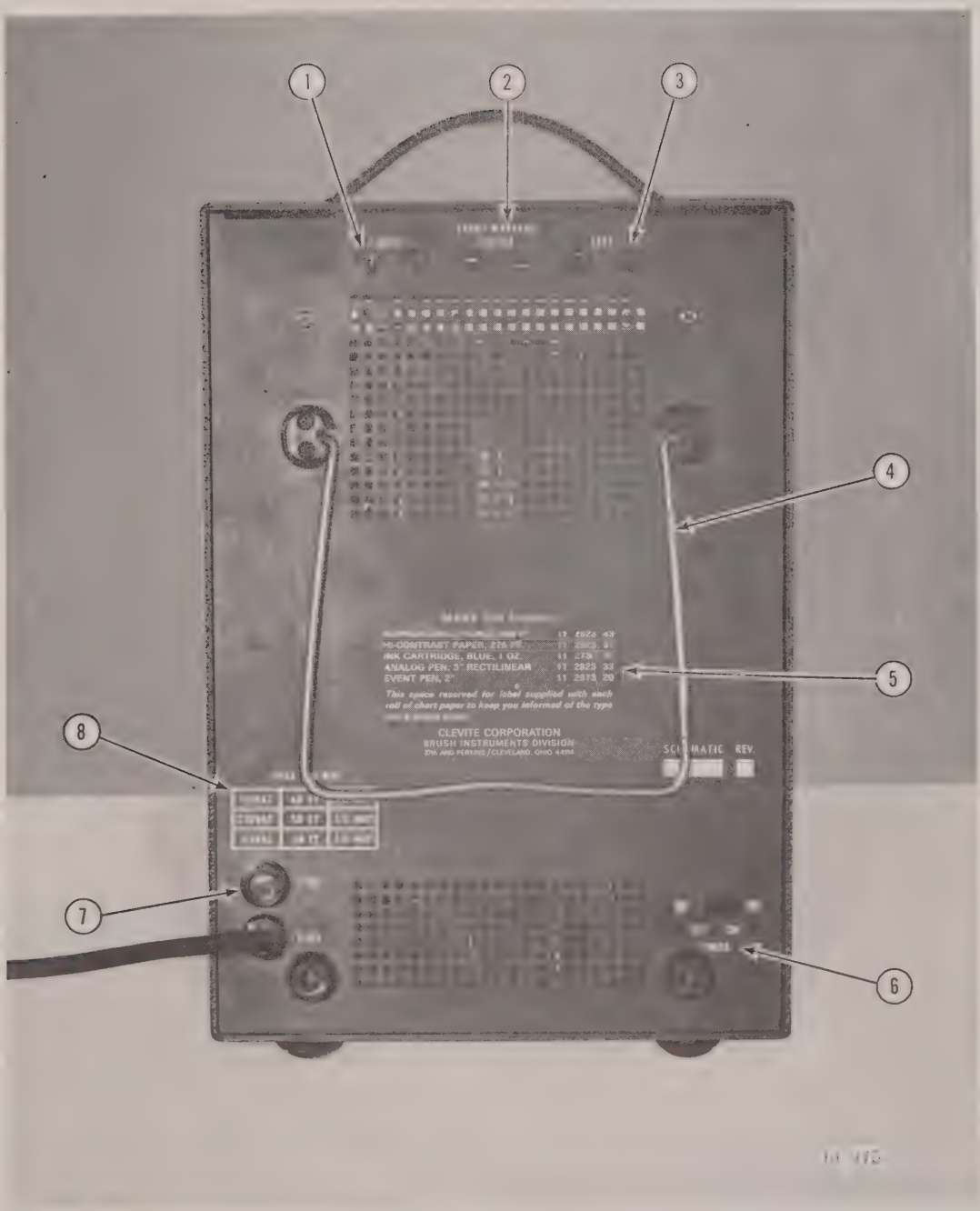


Figure 3-2 Mark 220 Recorder - Rear Panel Controls

(5)	Supplies List	A list of supplies by correct model number permanently silkscreened on the rear of recorder. Refer to this list when re-ordering supplies.
(6)	Internal Timer (optional)	Provides internal one-second pulses to actuate right event marker. When in the ON position, right event marker will be actuated by an internal timer at the rate of one pulse per second. When in the OFF position, the internal timer is inoperative.
(7)	Fuse	Line fuse, protects the recorder from damage if a serious malfunction should occur.
(8)	Fuse Table	A list of factory recommended ratings for fuses for various A.C. power source. CAUTION: This list does not imply that the recorder will operate at all the input sources listed. The recorder can only be operated from A.C. power source as indicated by the model number. Refer to Paragraph 2.3 for the correct A.C. source for the model being used.

3.4 OPERATION

CAUTION: Check to be sure all procedures in Section II have been performed.

1. Set SENSITIVITY control in off position.
2. Turn SENSITIVITY x1 control to full clockwise position (detent) and secure with locking knob.
3. Connect recorder to correct A.C. source, (refer to Para. 2.3).
4. Turn recorder ON, allow 15 minute warm-up.
5. Depress 1 mm/sec chart speed button.
6. Position pen at exact chart center or any other desired signal-zero location with POSITION control. Lock in place.
7. Apply input signal, refer to Paragraph 1.2b for input signal parameters.
8. Switch SENSITIVITY control to a range that will permit maximum deflection without going beyond chart edge.
9. Chart deflection will be proportional to the SENSITIVITY control setting for voltage being recorded.
10. Select a chart speed that will best display the signal with respect to recording frequency.
11. Unit is now ready for operation.

NOTE: Primary power is removed from recorder by paper interlock switch when paper supply is exhausted. Because of necessity of keeping paper under pens, some unused paper will remain on roll.

NOTE: When using this Recorder in conjunction with a Brush 4200 Series Preamplifier or a Brush 4300 Series Medical Coupler installed in a Brush Model 11-4123-10 Portable Carrying Case, proceed as follows to insure proper operation:

1. Set Recorder SENSITIVITY to OFF position.
2. Adjust Recorder PEN POSITON to exact chart center and lock knob.
3. Check that Recorder vernier SENSITIVITY X1 control is in detent position, and lock knob.
4. Set Recorder SENSITIVITY to 100 MILLIvolts per division.
5. Remove grounding strap from input terminals 2 and ground. A ground wire may be connected between pin 1 and ground.
6. Connect output cable from Preamplifier to input terminals 1 and 2, observing normal polarity (positive to pin 1, negative to pin2).
7. Proceed with operation, using controls on Preamplifier.

Observing this procedure will insure a positive input to preamplifier will result in left (positive) deflection of Recorder pen.

Section IV
Maintenance

4.1 GENERAL

This section describes and illustrates removal, installation, and adjustment procedures that can normally be performed by the operator.

4.2 CHANGING CHART PAPER

This paragraph describes and illustrates the procedures for changing the chart paper.

a. Removal

1. Press chart speed STOP button.

2. Turn recorder off.

3. Grasp pull bar (Fig. 4-1) on bottom of writing table and pull out and up to place writing table in open position.

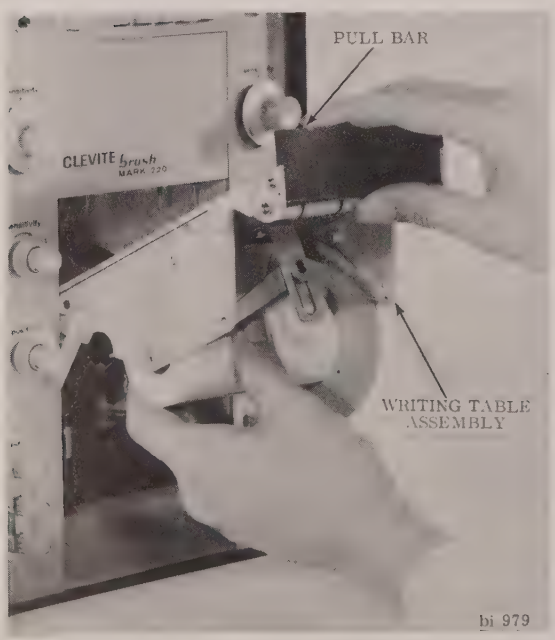


Figure 4-1 Changing Chart Paper (1 of 4)

4. Hold paper supply core and shaft and pull down on paper supply release lever (Fig. 4-2) and remove paper supply core and shaft.

5. Unscrew paper core from supply roll shaft and discard paper core.

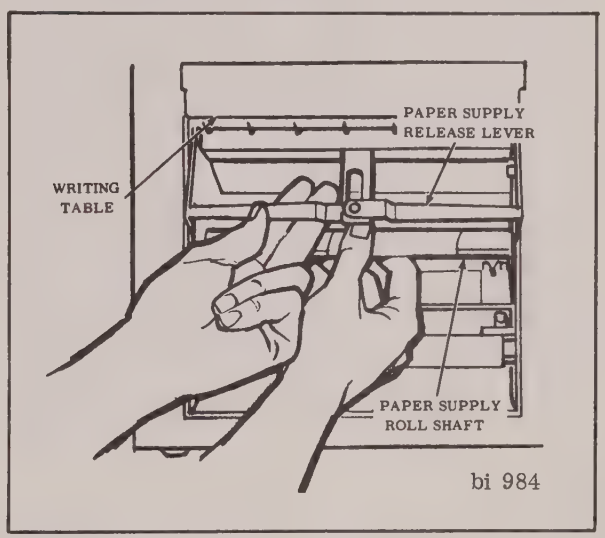


Figure 4-2 Changing Chart Paper (2 of 4)

b. Installation

1. Slide new roll of paper onto supply roll shaft.

NOTE: Check to be sure flange of shaft is at right side adjacent to channel 2 on chart paper and paper unwinds from top of roll.

2. Screw supply roll shaft into paper core so that flange is snug against paper core.

3. Insert flanged end of paper supply roll shaft into shaft mounting holes in writing table assembly (Fig. 4-3), and push up on release lever to lock shaft into position.

CAUTION: Check to be sure left end of supply roll shaft is seated in writing table assembly and supply roll shaft rotates freely.

4. Feed paper over writing bar, through slot in front of writing table, behind pressure roll and out front of writing table assembly (Fig. 4-4).

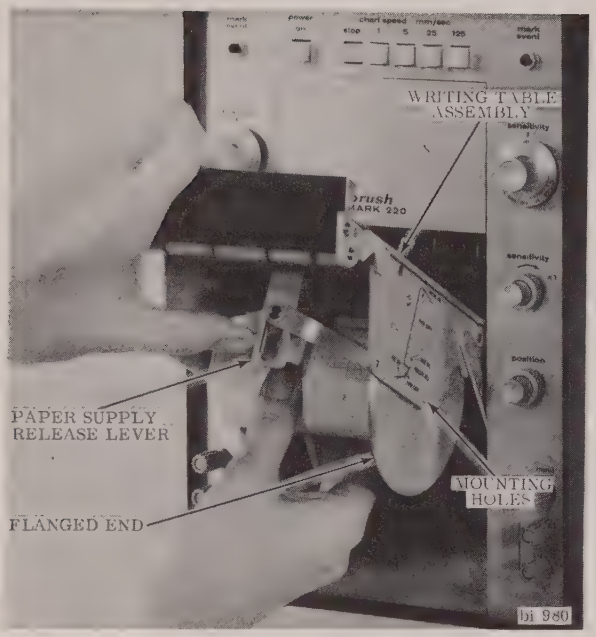


Figure 4-3 Changing Chart Paper (3 of 4)

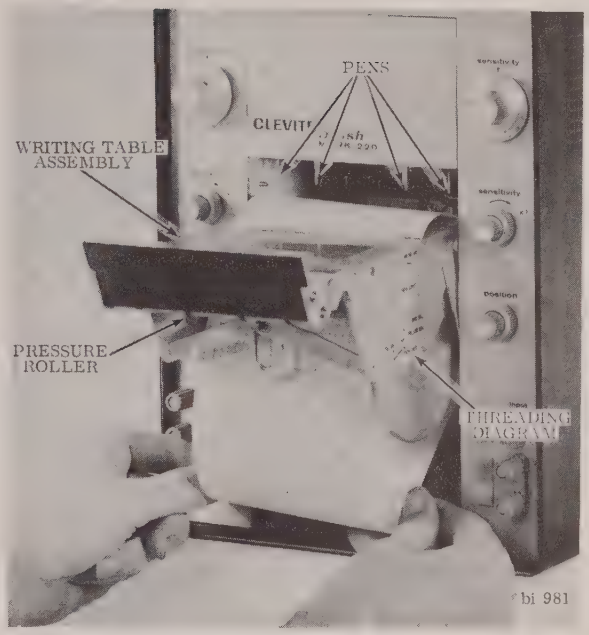


Figure 4-4 Changing Chart Paper (4 of 4)

NOTE: Refer to paper threading diagram on side of writing table assembly.

CAUTION: Use care during paper threading not to damage pens.

5. Slowly close writing table assembly while gently pulling on paper. When friction resists rotation of paper roll, pull paper taut, center on writing table, and close writing table.

NOTE: Check to be sure writing table is properly engaged by pressing on both sides of writing table.

6. Turn recorder on and operate at 125 millimeters per second to run about two feet of chart paper to align chart paper.

4.3 COVER ASSEMBLY

The cover assembly must be removed to perform certain maintenance and calibration procedures on the recorder.

WARNING: Check to be sure recorder is turned off and disconnected from A.C. power source.

a. Removal

1. Lay recorder on rear panel and remove four screws attaching rubber feet and cover assembly to bottom of recorder.

2. Return recorder to upright position.

3. Carefully slide recorder forward out of cover assembly.

b. Installation

1. Carefully slide recorder into front of cover assembly.

CAUTION: Check to be sure wires are not pinched between cover and recorder chassis.

2. Lay recorder on rear panel and install four screws attaching rubber feet and cover to recorder.

3. Return recorder to upright position.

4.4 REPLACING ANALOG PEN MODEL 11-2823-33

This paragraph describes and illustrates the procedures for removing and installing the analog pens.

a. Removal

1. Remove recorder cover assembly (Para. 4.3).

2. Remove pen access cover (located above writing table) by pulling out on bottom of access cover.

3. Use a screwdriver and rotate individual ink valve button to OFF position (Fig. 4-5).

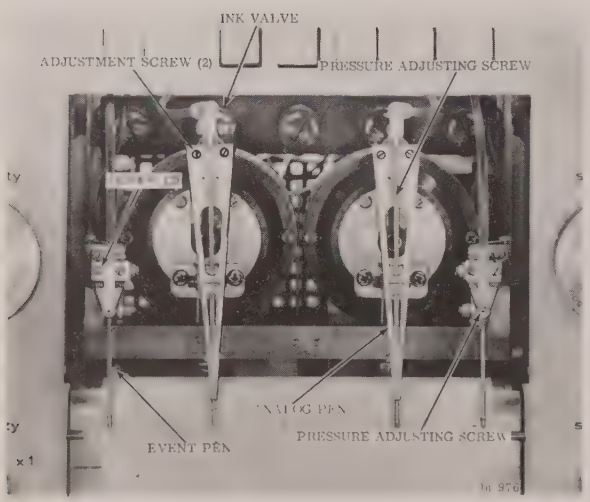


Figure 4-5 Replacing Analog Pen (1 of 2)

4. Gently remove pen ink tube from manifold nipple.

NOTE: Place a tissue under nipple and ink tube to prevent ink dripping on recorder components.

5. Use pen replacement wrench (part number 1-120922-2) and loosen set screw through access hole on side of penmotor drive arm shaft (Fig. 4-6) and remove wrench.

6. Remove pen from penmotor drive arm shaft.

NOTE: Do not loosen set screw more than one-half turn or pen cannot be removed from shaft.

b. Installation

1. Carefully slide replacement pen onto penmotor drive arm shaft.

2. Align set screw in pen hub with access hole in drive arm shaft and "snug up" set screw using pen replacement wrench. Remove wrench.

NOTE: Set screw should be tightened to create friction, but loose enough to allow pen to be rotated in penmotor hub.

3. Install pen ink tube onto manifold nipple being careful to avoid kinking or creasing.

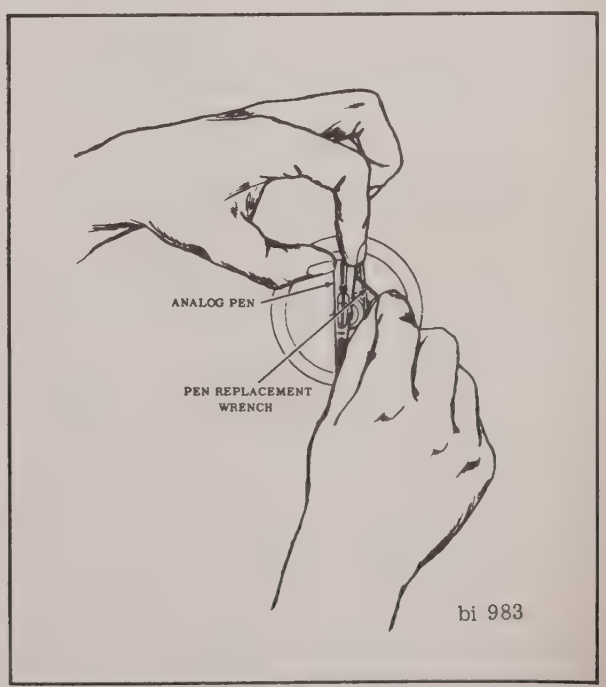


Figure 4-6 Replacing Analog Pen (2 of 2)

CAUTION: Do not use sharp instrument.

4. Use screwdriver and turn individual ink valve button to ON position.

5. Connect recorder to proper A.C. power source and turn on recorder POWER.

6. Use pen POSITION control, and place pen at chart center.

7. Operate recorder at five millimeters per second.

8. Lift pen slightly to allow ink to bleed through pen tip.

9. Press recorder chart speed STOP button and turn power off.

10. Gently grasp pen near hub and move pen across entire chart width (40 mm).

11. If ink trace is not parallel to a horizontal time line, gently turn pen in penmotor drive arm until trace is parallel to time line.

12. Use pen replacement wrench, tighten set screw securing pen in penmotor drive arm shaft and remove wrench.

13. If pen tip is not on same time line as other pens, loosen two pan head adjustment screws (Fig. 4-5) and slide pen up or down until all pen tips are on same time line, and tighten screws.

14. Check pen pressure and adjust if required (Para. 4.7 and 4.8).

15. Lap pen if trace is not dry to touch with recorder operating at five millimeters per second (Para. 4.9).

16. Install pen access cover.

17. Install recorder cover assembly (Para. 4.3).

4.5 REPLACING EVENT PEN MODEL 11-2873-20

This paragraph describes and illustrates removal and installation of the event marker pen.

a. Removal

1. Remove recorder cover assembly (Para. 4.3).

2. Remove pen access cover (located above writing table) by pulling out on bottom of access cover.

3. Use a screwdriver and rotate event marker individual ink valve button to OFF position.

4. Gently remove pen ink tube from manifold nipple (do NOT use sharp instrument).

NOTE: Place a tissue under nipple and ink tube to prevent ink dripping on recorder components.

5. Loosen two screws attaching pen to event marker and remove pen from event marker (Fig. 4-6).

b. Installation

1. Slide replacement pen onto event marker and align pen tip on vertical grid line and on same time line as analog pen.

2. Tighten two screws attaching pen to event marker (Fig. 4-6).

3. Install pen ink tube onto manifold nipple being careful to avoid kinking or creasing.

4. Use screwdriver and rotate event marker ink valve button to ON position.

5. Connect recorder to proper A.C. power source and turn on recorder POWER.

6. Operate recorder at five millimeters per second.

7. Lift pen slightly to allow ink to feed through pen tip.

8. Check pen pressure and adjust if required (Para 4.7 and 4.8).

9. Lap pen if trace is not dry to touch with recorder operating at five millimeters per second (Para. 4.9).

10. Install recorder cover assembly (Para. 4.3).

4.6 REPLACING PENMOTOR BAND ASSEMBLY

The penmotor band assembly (part number 241231-910) should not be removed unless broken. Because the band tension is critical, a band replacement tool (part number 341409-915) must be used to replace band assembly.

NOTE: Penmotor need not be removed from recorder.

a. Removal (Fig. 4-7)

1. Remove analog pen (Para. 4.4).

2. Remove socket-head screw and band clamping (curved) washer that secures band assembly to drive arm.

3. Remove two socket-head screws and lock washers securing band assembly to drive arm bracket. Discard damaged band assembly.

4. Position new band assembly around drive arm hub and install band clamping washer and socket-head screw. Do not tighten screw.

CAUTION: To prevent damage to the new band assembly, check to be sure drive arm and bracket are free of nicks, dirt, ink before installing new band assembly.

NOTE: Check to be sure curved portion of washer is positioned to conform to the radius of the drive arm hub. Use care not to nick or scratch band assembly with tools or finger nails.

5. Align band assembly mounting holes with tapped holes in drive arm bracket and install two screws and lock washers. Do not tighten screws.

6. Inspect band for proper positioning around drive arm hub so that equal pressure is maintained on top and bottom of band assembly.

7. Install band tool on penmotor and thread knurled thumb screw into drive arm bracket.

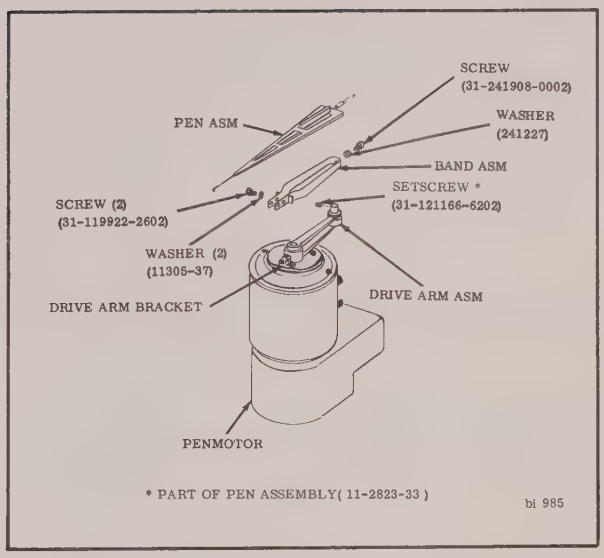


Figure 4-7 Penmotor Band Assembly

8. Depress plunger and insert locking pin into two small holes of band assembly, making certain plunger is behind locking pin.

9. Tighten two screws in drive arm bracket, loosen one quarter-turn, move drive arm back and forth several times to center band assembly and tighten screws.

10. Move drive arm back and forth several times to center band assembly on drive arm and tighten socket-head screw securing band assembly to drive arm.

NOTE: Do not tighten more than 22 inch-ounces.

11. Depress plunger and remove locking pin.

12. Loosen knurled screw securing band tool to drive arm bracket and remove tool.

13. Apply glyptal cement (or equivalent) to heads of the three screws to prevent working out.

14. Install analog pen (Para. 4.4).

4.7 PEN PRESSURE MEASUREMENT

Analog or event marker pen pressure should be

checked if the ink trace is excessively wide (bleeding), indicating low pen pressure or if pen gouges the chart paper, indicating excessive pen pressure.

NOTE: Wide trace may also indicate an improperly lapped pen. Refer to Paragraph 4.9 for pen lapping procedures.

The gram gage (part number 240601-910) is used to measure the pressure of the analog and event marker pens as follows:

1. Turn SENSITIVITY control to OFF position.

2. Depress POWER ON button to turn on recorder.

3. Remove pen access cover (located above writing table) by pulling out the bottom of access cover.

4. Press the 1 MM/SEC chart speed button.

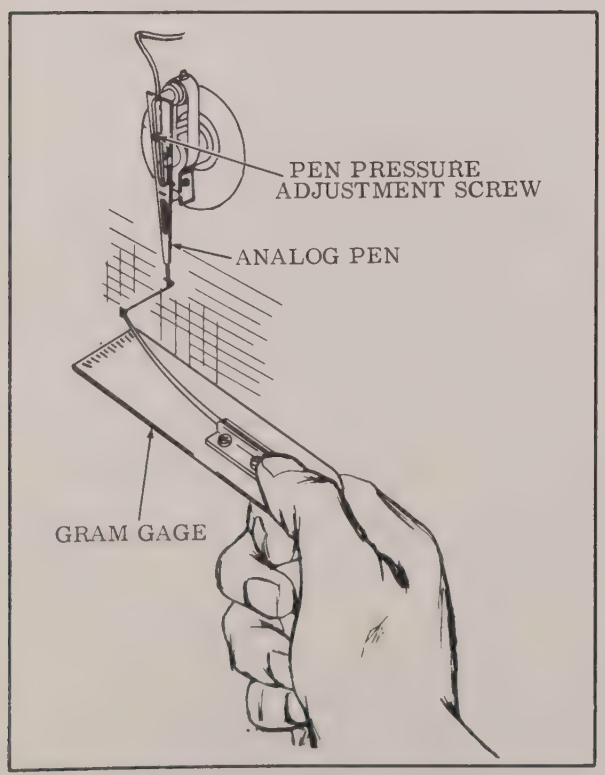


Figure 4-8 Pen Pressure Measurement

5. Place gram gage hook under pen shaft as close as possible to tip and form a right angle to pen shaft with gage hook (Fig. 4-8).

6. Pull pen from chart and take reading on gage the moment excessive ink starts to flow from pen.

7. Proper writing pressure for analog pens is 28 to 32 grams. Event marker pen pressure is 20 to 25 grams.

NOTE: If pen pressure reading is not within specification, refer to Paragraph 4.8 for pen pressure adjustment.

8. If pen pressure is correct for analog and event pens, install access cover. Recorder is ready for operation.

4.8 PEN PRESSURE ADJUSTMENT

When pens are replaced, pen pressure must be checked (Para. 4.7) and if required, adjust as follows:

1. Use pen pressure adjustment wrench (part number 1-120922-18) and turn adjusting screw (Figs. 4-6 and 4-9) clockwise to increase pressure or counterclockwise to decrease pressure.

2. Check pen pressure with gram gage (Para. 4.7) and continue adjustment until proper reading is obtained.

3. Install pen access cover. Recorder is ready for operation.

4.9 PEN LAPPING

a. General

This paragraph describes and illustrates the proper procedures for lapping the analog and event pens. Intermittent or "wet" ink trace are indications that pen pressure is incorrect or that pen requires lapping. Check for "wet" writing by

Figure 4-9 Pen Pressure Adjustment

operating the recorder at five mm/sec chart speed, with the SENSITIVITY control in OFF position. Check pen trace by wiping index finger, with moderate pressure, across trace approximately one inch below pen tip. If ink does not smear, the pen is properly lapped. If trace smears, check and adjust pen pressure (Para. 4.7 and 4.8). Repeat test, and if trace continues to smear, lapping is required.

b. Lapping Procedure.

NOTE: Lapping of pens should only be done when required.

1. Turn recorder OFF.

2. Remove pen access cover (located directly below chart speed selector switch) by pulling on bottom of access cover.

3. Carefully raise pen tip just enough to slide a small strip of emery paper (4/0) under pen tip.

CAUTION: Do not use a coarse or very abrasive type of emery paper. Use only the grade specified.

4. Move emery paper back and forth under pen tip, parallel to chart time lines, for a total distance of approximately two inches. (Fig. 4-10).

CAUTION: Make sure that emery paper is held flat against the chart paper to insure proper lapping of pen.

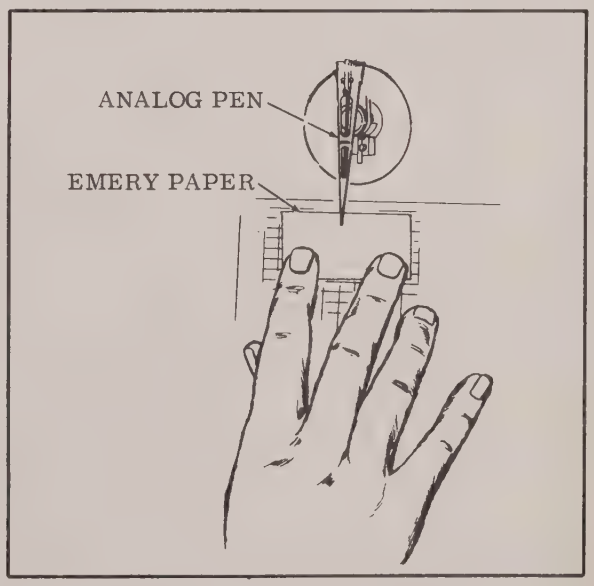


Figure 4-10 Pen Lapping

5. Remove emery paper, operate recorder at five mm/sec and check pen trace for dryness.

6. Repeat steps 1 thru 5 as required to obtain dry trace.

NOTE: If procedure is repeated more than three times, recheck pen pressure and repeat lapping. Strict adherence to above lapping procedures is imperative.

8. When dry trace is achieved, replace access cover.

4.10 INK CARTRIDGE REPLACEMENT

This paragraph describes and illustrates the procedures for replacing the Ink Cartridge, Model 11-2730-01.

a. Removal

1. Remove recorder cover assembly (Para. 4.3).

2. Remove four screws and lock washers (two screws and lock washers located inside rubber mounts) attaching rear panel to recorder and carefully move rear panel free and clear of work area.

CAUTION: Power cable, fuse lead, and event marker leads will remain attached to rear panel. Exercise care when moving panel so that leads are not broken.

3. Turn activating screw (Fig. 4-11) clockwise until compression spring in ink plunger has been drawn up tight into ink plunger assembly and ink flow stopped.

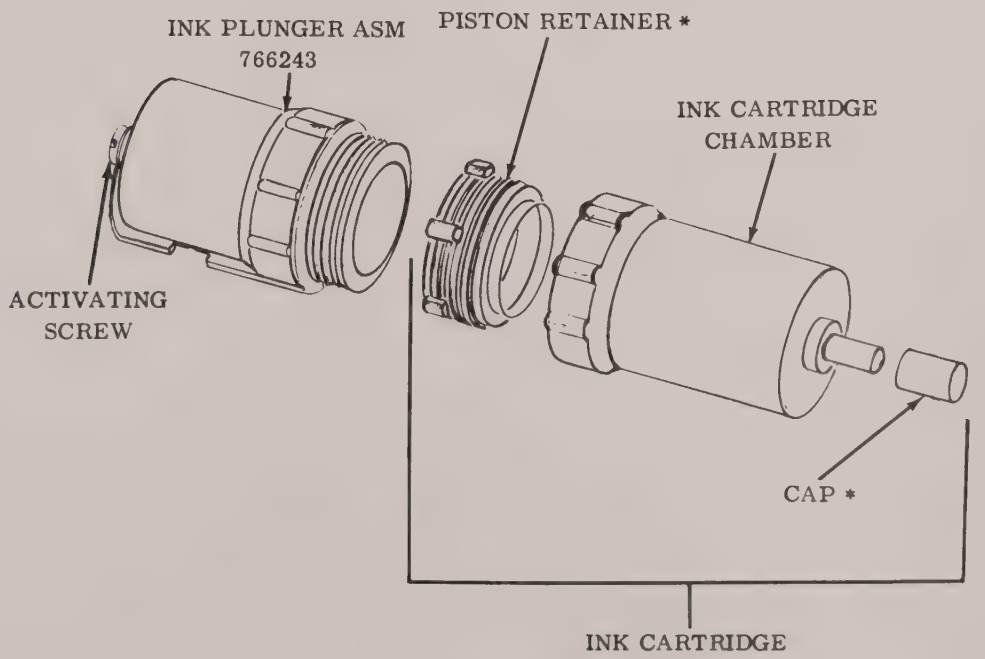
CAUTION: Place paper towels or tissues under ink system to prevent ink dripping on recorder components.

4. Carefully remove ink tube adapter assembly from ink cartridge.

5. Unscrew ink cartridge chamber from plunger assembly and discard cartridge.

b. Installation

1. Remove plastic piston retainer ring from replacement cartridge and discard retainer (Fig. 4-11).



* SHIPPING ITEMS - TO BE DISCARDED

Figure 4-11 Ink Cartridge, Model 11-2730-01

2. Install ink cartridge in plunger assembly and tighten securely.

3. Remove shipping cap from ink cartridge and discard shipping cap.

4. Install ink tube adapter assembly on cartridge.

NOTE: Do not use tweezers or other sharp instruments to install adapter.

5. Turn activating screw (Fig. 4-11) counter-cockwise until snug to pressurize ink system.

6. Install recorder rear panel using four screws and lock washers and two rubber feet.

7. Connect recorder A.C. power cable to proper power source.

8. Turn recorder on and operate recorder at a chart speed of five millimeters per second.

9. Gently raise each pen tip away from paper and allow ink tube to fill with ink and bleed air from tube until no air bubbles are formed at pen tip.

10. Press recorder STOP button and disconnect A.C. power cord from source.

11. Install recorder cover assembly (Para. 4.3).

4.11 PEN CLEANING

In the event that a pen should fail to write or displays intermittent writing, it may be caused by a clogged pen. The procedure outlined below is intended as a guide to flush pens, but may not always prove effective.

1. Turn recorder off.

2. Close ink valve on affected channel.

3. Remove ink tubing from manifold.

4. Remove pen (Para. 4.4a or 4.5a).

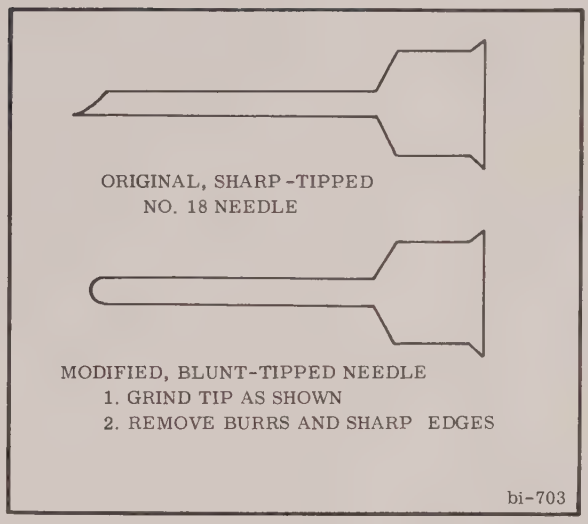


Figure 4-12 Hypodermic Needle Modification

NOTE: Do not remove tubing from pen unless tubing is kinked or suspected of being defective. Use Brush part number 667277 for analog pen tubing and part number 666587 for event pen tubing.

5. Modify hypodermic needle per Fig. 4-16.

NOTE: Modified hypodermic needle and syringe assembly is Brush part number 125160-501.

6. Attach modified needle onto 2cc hypodermic syringe.

7. Insert needle in pen tubing.

8. Immerse pen tip in cleaning agent. (Isopropyl Alcohol, Cell-O-Solve or equivalent).

9. Back-flush by slowly withdrawing syringe plunger.

NOTE: It may be necessary to allow the pen to remain in the cleaning agent to dissolve dried ink at pen tip.

10. Install pen (Para. 4.4b or 4.5b).

NOTE: Clogging of pens occurs only when proper adjustment, operating and/or handling as per Brush Operating Manual has not been adhered to.

Section V
Calibration

5.1 GENERAL

The Mark 220 Recorder has been factory calibrated, and under normal conditions will not require calibration. However, because of parts replacement or repair, calibration may be necessary. This section describes and illustrates the correct procedures. It should be pointed out that calibration should only be performed by qualified personnel familiar with procedures and standards.

5.2 TEST EQUIPMENT

The following is a list of recommended test equipment necessary for calibration.

NOTE: Specific manufacturer need not be adhered to, but comparable equipment is mandatory, since accuracy stated is imperative.

a. Function Generator (Hewlett-Packard, Model 202A or equivalent).

b. D.C. Power Supply, 25 mv to 5.0 volts ±0.1% (floating)

NOTE: To check for maximum D.C. capabilities, a D.C. power supply capable of 500 volts will be required. If the accuracy of the D.C. power supply is in doubt, or not accurate to 0.1%, it will be necessary to monitor the D.C. supply while making critical adjustments. This may be accomplished with a differential voltmeter (Fluke, Model 803B, or equivalent).

c. Oscilloscope, (Tektronix, Type 503, or equivalent).

5.3 PERFORMANCE CHECK

NOTE: All performance checks and calibration procedures are typical for both channels.

Perform the following checks on the Mark 220 to determine proper adjustment. If the recorder does not meet the requirements calibration will be necessary.

NOTE: Unless otherwise instructed all procedures are performed with the ground strap connected between terminal 2 and G (ground).

a. D.C. Check

1. Set SENSITIVITY control to OFF.
2. Set SENSITIVITY x1 control full clockwise to x1 (detent) position.
3. Turn recorder on and allow 15 minute warm-up.
4. Operate recorder at five millimeters per second.
5. Position pen at exact chart center with pen POSITION control.
6. Apply a +25 mv D.C. signal to input of recorder.
7. Rotate SENSITIVITY control to 1 MV/DIV position. Pen deflection should be 25 divisions to left chart edge.
8. Switch polarity of the input voltage to -25 mv. Pen deflection should be 25 divisions to right chart edge.
9. Remove input signal, and check that pen returns to chart center.

b. A.C. Check

1. Set SENSITIVITY control to OFF.
2. Operate recorder at five millimeters per second.
3. Check that pen is at chart center.
4. Apply 50 mv peak-to-peak A.C. signal, at 10 cps.
5. Set SENSITIVITY control to 1 MV/DIV.

6. Pen deflection should be full scale (50 div) ±1.0 division.

7. Increase frequency to 40 cps.

8. Pen deflection should not change by more than one division when frequency is increased from 10 cps to 40 cps.

NOTE: It is important at this point to be positive the output voltage from the function generator is flat from 10 cps to 40 cps, and that function generator output does not contain any D.C. offset voltage.

5.4 CALIBRATION

If recorder did not meet requirements of Performance Check (Para. 5.3), remove cover assembly (Para. 4.3) and perform the adjustments described and illustrated in this paragraph.

a. Balance Adjustment

1. Connect recorder to A.C. power source.

2. Set SENSITIVITY control to OFF.

3. Turn recorder on and allow 15 minute warm-up.

NOTE: Before continuing to step 4, run chart at one millimeter per second. Rotate pen POSITION control full clockwise and adjust right limit control (Fig. 5-1) so that pen travel is at least two divisions beyond chart edge. Rotate pen POSITION control full counterclockwise and adjust left limit control (Fig. 5-1) so that pen travel is at least two divisions beyond chart edge.

4. Disconnect drive amplifier input by carefully removing white/black/brown wire from quick disconnect point (1) Figure 5-1.

5. Connect one end of test clip lead to drive amplifier input (1) Figure 5-1.

6. Alternately open and short input to ground (chassis).

7. Adjust BALANCE control (Fig. 5-1) for minimum pen movement when opening and shorting to ground.

b. Zero Adjustment

1. Connect clip lead from drive amplifier input terminal (1), (Fig. 5-1) to recorder ground on front panel.

2. Center pen by adjusting ZERO control located on amplifier board (Fig. 5-1).

3. Disconnect clip lead from amplifier input to ground.

c. Gain Adjustment

1. Turn recorder power off.

2. Disconnect penmotor drive coil from drive amplifier output by removing brown wire from quick-disconnect point (2), (Fig. 5-1).

3. Connect a 45 ohm ±1%, 5 watt resistor from output pin to ground (chassis).

4. Turn recorder power on.

5. Apply a 200 millivolt peak-to-peak signal at 100 cps to input of drive amplifier (1), (Fig. 5-1) and ground.

4. Monitor signal across 45 ohm resistor and adjust GAIN control (Fig. 5-1) for 20 volts peak-to-peak.

5. Remove 45 ohm resistor, and replace brown lead to drive amplifier output.

6. Replace white/black/brown lead to drive amplifier input.

d. Preamplifier Balance Adjustment

1. Turn SENSITIVITY control to OFF position.

2. Operate recorder at a chart speed of five millimeters per second.

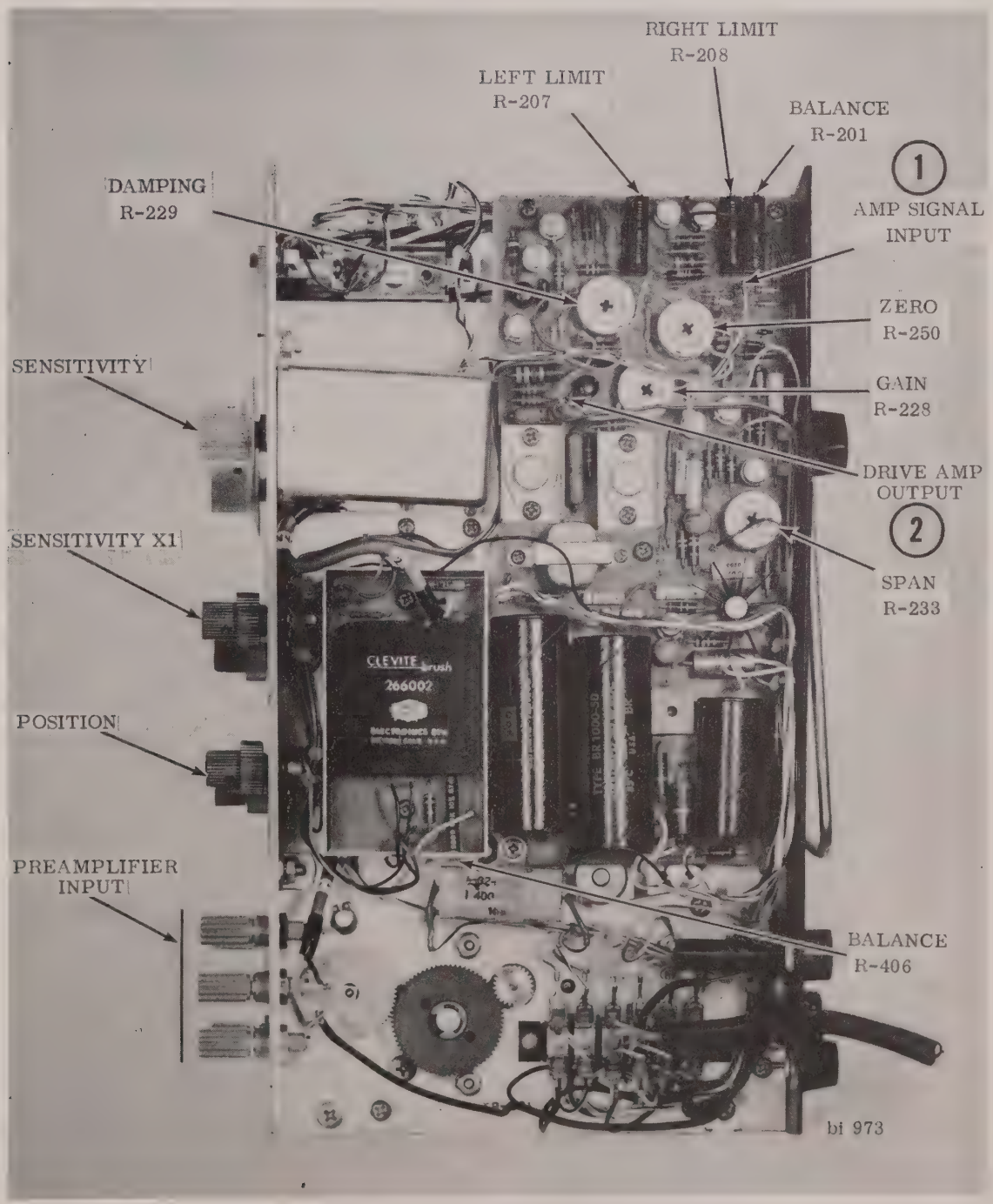


Figure 5-1 Calibration Controls - Right Side Shown, Left Side Similar

3. Use pen POSITION control and set pen at chart center.

4. Rotate variable SENSITIVITY x1 control throughout its entire range several times and check for any pen deflection.

5. If no pen deflection is observed, preamplifier is properly balanced.

6. If observed pen deflection is greater than 1/4 chart division, adjust preamplifier BALANCE control (Fig. 5-1) for no pen deflection while rotating SENSITIVITY x1 control throughout entire range.

e. Span Adjustment

1. Operate recorder at a chart speed of five millimeters per second.

2. With pen POSITION control, set pen at chart center.

3. Set variable SENSITIVITY x1 control in full clockwise (detent) position.

NOTE: Ground strap should be in place.

4. Apply a 2.500 ±.005 volts D.C. signal to input terminals.

5. Set SENSITIVITY control in 100 MV/DIV position.

6. Pen should deflect exactly 25 divisions to left. If not, adjust SPAN control (Fig. 5-1) for exactly 25 divisions.

7. Reverse polarity of input signal. Pen deflection should be 25 divisions to right.

NOTE: If pen does not deflect 25 divisions repeat ZERO adjustment (step b) and SPAN adjustment.

e. Frequency Response

1. Set SENSITIVITY control in OFF position.

2. Set SENSITIVITY x1 control full clockwise in x1 position.

3. Run chart at five millimeters per second.

4. Center pen on chart with position control.

5. Set SENSITIVITY control to 100 MV/DIV.

6. Apply a 10 cps sine wave signal to input terminals on front panel.

7. Adjust sine wave generator for deflection of exactly 10 divisions peak-to-peak.

8. Switch generator to 100 cps and adjust DAMPING control (Fig. 5-1) for 10 divisions peak-to-peak.

9. Switch to 10 cps and check for 10 divisions peak-to-peak deflection. Adjust generator if required.

10. Repeat steps 8 and 9 until there is no difference between the deflection at 10 cps and 100 cps.

11. Switch frequency to 4 cps.

12. Adjust generator for 50-division (full scale) deflection.

13. Switch frequency to 40 cps.

14. Adjust DAMPING control for 50 division deflection.

15. Switch frequency to 4 cps and check for 50 division deflection. Adjust generator if required.

16. Repeat steps 11 thru 14 until there is no difference between the deflection at 4 cps and 40 cps.

NOTE: The maximum allowable error is ±1.0 division full scale.

17. Disconnect input signal.

f. Square Wave Response

If the primary concern for data results is square wave response and not frequency response, perform the procedures described in this paragraph. However, if frequency response is the primary concern do NOT perform procedures described in this paragraph and proceed to paragraph g, since some frequency response will be sacrificed for best square wave results.

1. Set SENSITIVITY control to OFF.
2. Apply a 1 cps square wave signal to input terminals on front panel.
3. Operate recorder at chart speed of 25 millimeters per second.
4. Set SENSITIVITY control to 100 MV/DIV position.
5. Adjust generator for 25-division peak-to-peak deflection.
6. Adjust DAMPING control for best square waveform reproduction (minimum overshoot).
7. Disconnect input signal.

g. Limit Adjust

1. Set SENSITIVITY control to OFF position.
2. Operate recorder at a chart speed of one millimeter per second.
3. Turn POSITION control full counterclockwise.
4. Adjust LEFT LIMIT control (Fig. 5-1) to bring pen to 2 divisions beyond chart edge.
5. Turn POSITION control full clockwise.
6. Adjust RIGHT LIMIT control (Fig. 5-1) to bring pen to 2 divisions beyond chart edge.

h. Completion

If all calibration procedures have been performed for both channels in the prescribed sequence and the parameters have been correct, the unit will be calibrated to the original factory specifications. No further checks or procedures are required. Disconnect all calibration signals and install recorder cover assembly (Para. 4.3b).

Section VI
Theory of Operation

6.1 GENERAL

The Mark 220 Recorder consists of two analog channels, associated preamplifiers, penmotor drive amplifiers and power supplies (Fig. 6-1). The input signal to each channel is differential balanced-to-ground or single-ended by use of ground strap. Attenuation of input signal is accomplished by controls on the front panel.

Penmotor drive amplifier is a complete servo-type system utilizing a Metrisite transducer in the penmotor to develop position and a tachometer generator to derive velocity.

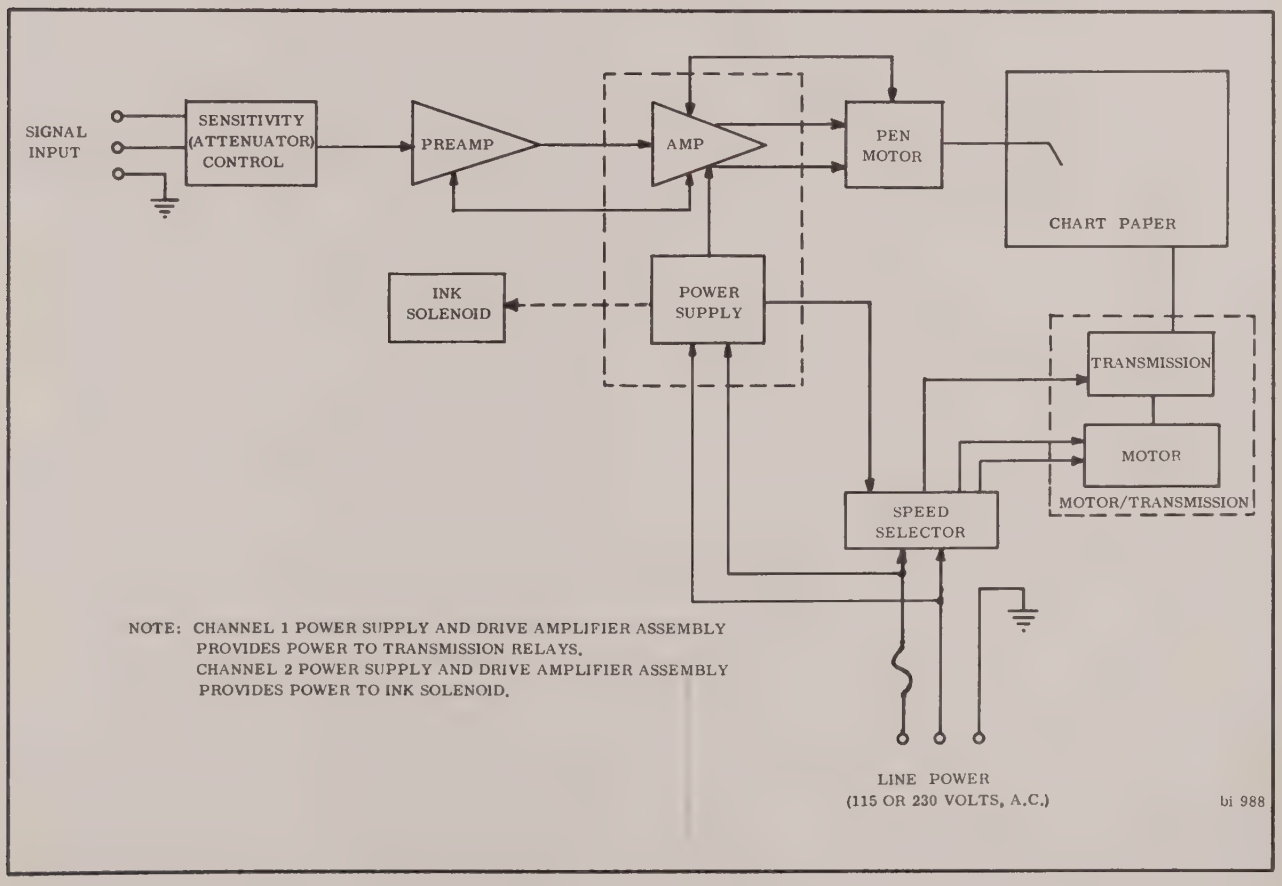


Figure 6-1 Mark 220 Recorder - Functional Block Diagram

6.2 DETAILED DESCRIPTION

a. Regulated D.C. Power Supply Circuit (Fig. 6-2)

Primary power is applied to transformer, T-301 and rectified by full wave rectifier bridge, CR 215. The common output point of transformer, T-301, is tied to ground. The output voltages, +32 volts D.C. and -32 volts D.C. are applied to the output stages of the drive amplifier. Regulated plus and minus 18 volts to amplification stages of drive amplifier are derived from dropping resistors, R-213 and R-221, and by zener diodes CR-209 and CR-210. Regulated plus and minus 5.6 volts D.C. are applied to pen POSITION control, R-302, through dropping resistors, R-212 and R-214 and zener diodes CR-207 and CR-208. Regulated +5.6 volts are applied to amplifier ZERO control, R-250.

b. Drive Amplifier and A.C. Feedback Circuit (Fig. 6-2)

The drive amplifier acts as an error amplifier in that the input signal is constantly compared with pen position and assures that pen position on the chart accurately displays the input signal.

The summing of the amplifier is at the base of transistor, Q-203. The input signal is summed thru resistor R-210. The demodulated signal from the position sensing transducer (Metrisite) is summed thru resistor R-215. Resistor, R-209, serves as a summing resistor for the zero adjustment current thru ZERO control (R-250). Resistor, R-217, serves as the open-loop feedback path for the amplifier and with GAIN control (R-228) permits adjustment of the system for optimum frequency response. Resistor, R-216, sums the velocity feedback signal which is derived from a tachometer generator within the penmotor. DAMPING control, R-229, permits adjustment for optimum square waveform reproduction.

Any error voltage is amplified by transistors, Q-203, Q-204 and Q-205 and is then applied to transistors, Q-206 and Q-207, which form a phase-splitting driver stage for the output transistors, Q-208 and Q-209.

c. Left and Right Limiter Circuit (Fig. 6-2)

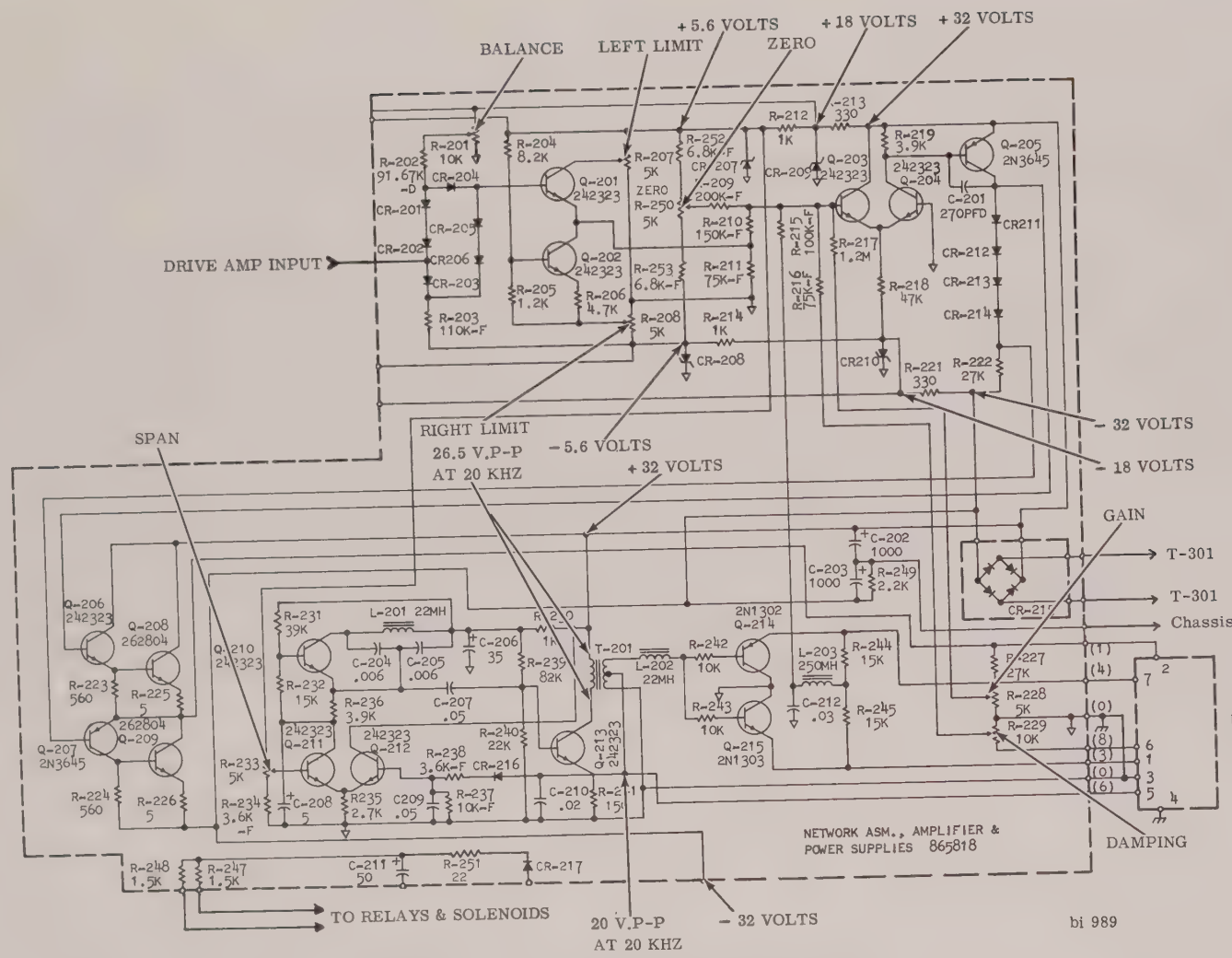
The output of the preamplifier is applied to the base of an emitter-follower transistor, Q-201, through diode network CR-201, CR-202, CR-203, CR-204, CR-205 and CR-206. The diode network provides the necessary bias and temperature compensation to assure a stable output from the limiters. Transistor Q-202 functions as a current source and emitter load for transistor Q-201. RIGHT LIMIT adjust, R-208, and LEFT LIMIT adjust, R-207, limit the voltage swing of transistor Q-201 which instantaneously clips any excess voltage applied to the limiters.

d. 20 KC Oscillator and Demodulator Circuits (Fig. 6-2)

The 20 KC Oscillator is basically a Colpitts'-type with a variable amplitude control. The oscillator is formed by transistor, Q-210, which derives its regeneration feedback from the tank circuit composed of reactor, L-201, and capacitors C-204 and C-205. Biasing of the oscillator is controlled by transistor Q-211. The variable amplitude of the oscillator output is adjusted by SPAN control (R-233) which changes the bias of transistor, Q-210 and consequently the output voltage of the oscillator which normally is 26.5 volts peak-to-peak.

The oscillator output voltage is then amplified by transistor, Q-213 and further stepped up by transformer, T-201, which has a center-tapped secondary winding providing two outputs. One output is applied to primary of position-sensing transducer (Metrisite). This same output is rectified by diode, CR-216, and is applied to the base of transistor, Q-212, thru resistor, R-238. Therefore, any change in output amplitude from transformer, T-201, will be sensed and corrected assuring stable oscillator output amplitude.

The second output voltage of transformer, T-201 is applied thru reactor, L-202, (phase-sensitive coil) to the phase-sensitive demodulator consisting of transistors, Q-214 and Q-215, and resistors R-242, R-243, R-244, and R-245.



NOTE: ALL VOLTAGES ARE D.C., EXCEPT AS NOTED.

Figure 6-2 Amplifier and Power Supplies Network Assembly 865818

The varing output voltage from the Metrisite is then applied to the demodulated circuit across resistors, R-244 and R-245. The demodulated and filtered output of the demodulator circuit is then applied to the error amplifier thru resistor, R-215.

e. Sensitivity (Attenuator) Control and Preamplifier Circuits (Fig. 6-3)

Input signals are applied to the balanced attenuator network consisting of resistors R-101 thru R-126. The differential input signal from the attenuator network is applied to the input of the preamplifier module, AR-401, thru protective resistors, R-401 and R-402.

With the variable SENSITIVITY control (R-301/S-302) in the detent (x1) position, the preamplifier assembly operates at a gain of 100 which is set by resistor, R-403. The variable SENSITIVITY control places a portion of resistor, R-301, in series with resistor, R-403, and varies the gain down to 40. The single-ended output of the preamplifier assembly is applied to the drive amplifier thru the limiter circuit.

Pen position voltage, from the wiper arm of POSITION control, R-302, is applied to a reference terminal of preamplifier module, AR-401.

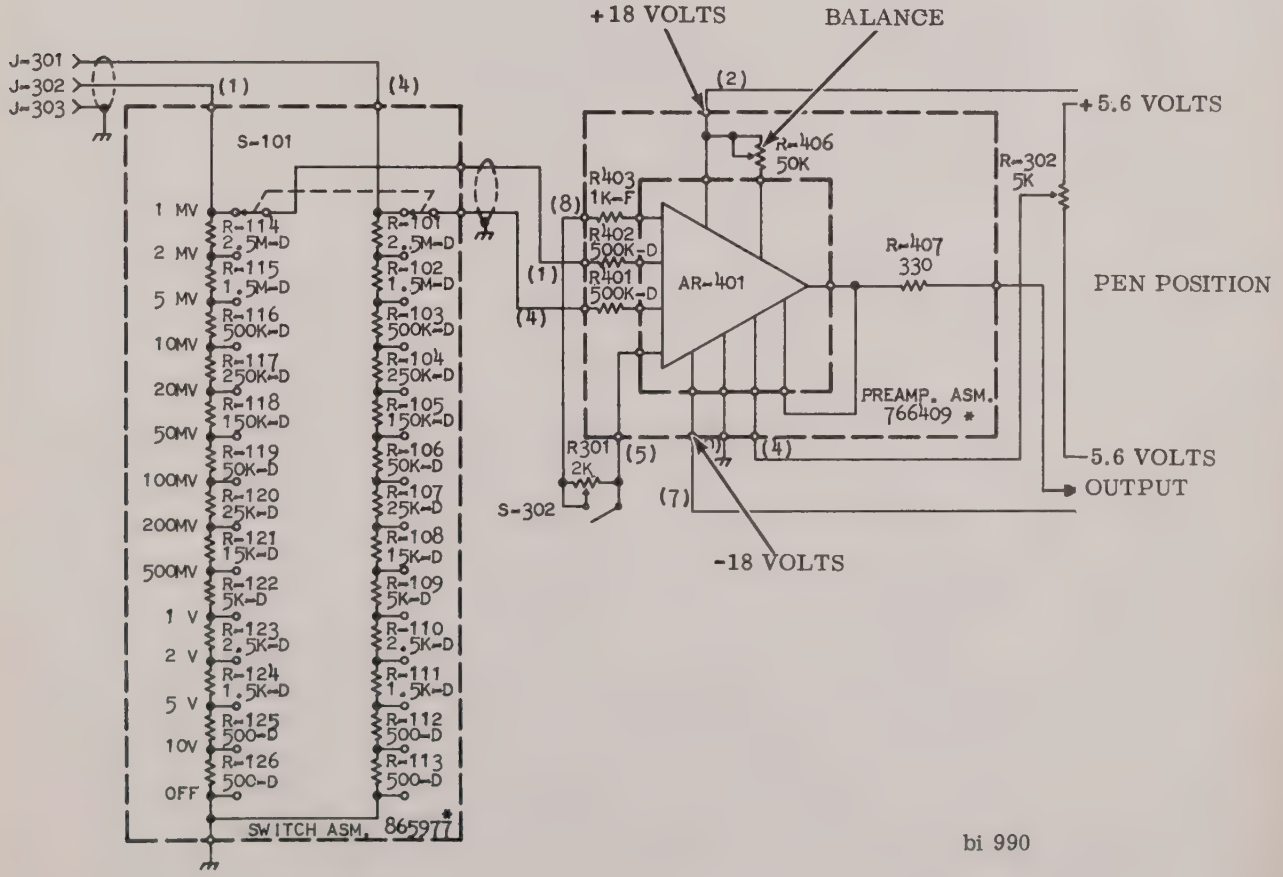


Figure 6-3 Preamplifier and Sensitivity Switch Circuits

Section VII
Troubleshooting

7.1 GENERAL

This section contains a troubleshooting table to assist operating personnel in isolating malfunctions that may occur during normal operation of the Mark 220 Recorder.

CAUTION: Any service that may be required in this section should be performed only by qualified service personnel.

7.2 TROUBLESHOOTING TABLE

MALFUNCTION	CAUSE	REMEDY
1. Recorder inoperative	a. Main power not connected to source.	a. Connect power to source
	b. Power ON-OFF switch in OFF position	b. Depress switch to ON position
	c. Blown fuse	c. Replace fuse (F-301 Slo-Blo)
	d. Open interlock	
	1) Paper supply exhausted	1) Install new roll
	2) Writing table not engaged properly	2) Engage properly
	e. Defective interlock switch	e. Repair and/or replace
	f. Defective ON-OFF switch	f. Replace
2. No power to pens (pens limp)	a. Power ON-OFF switch in OFF position	a. Switch to ON position
	b. Blown fuse	b. Replace fuse (F-301 Slo-Blo)
	c. Main power not connected to source	c. Connect to correct power source
3. Chart paper drive does not operate	a. Power switch in OFF position	a. Switch to ON position
	b. Chart speed STOP button depressed	b. Select correct chart speed
	c. Paper supply exhausted	c. Install new roll
	d. Writing table improperly engaged	d. Engage properly
	e. Defective interlock switch	e. Repair and/or replace

MALFUNCTION	CAUSE	REMEDY
3. (Continued) Chart paper drive does not operate	f. Defective motor/transmission	f. Replace
4. Chart paper speed is not as indicated by chart speed buttons, or chart speed does not change as chart speed buttons are depressed	a. Incorrect line voltage and/or frequency	a. Check for correct line voltage and frequency
	b. Defective chart speed selector switch	b. Repair and/or replace
	c. Defective motor/transmission	c. Replace
5. Pen writes intermittently or not at all	a. Insufficient writing fluid supply	a. Replace ink cartridge (Para. 4.9)
	b. Pen clogged	b. Clean pen (Para. 4.11)
	c. Ink valve off	c. Turn ink valve to ON position (Fig. 4-5)
6. Pen trace extremely heavy	a. Improper pen pressure	a. Adjust pen pressure (Para. 4.6 & 4.7)
	b. Pen not in full contact with paper	b. Lap pen (Para. 4.8)
	c. Pen not in contact with paper, due to wear on tip of pen	c. Replace pen (Para. 4.3)
	d. Noise coming thru drive amplifier, or signal source	d. Eliminate noise source
7. Pen gouges or tears paper	a. Improper pen pressure	a. Adjust pen pressure (Para. 4.7)
	b. Paper not centered	b. Center paper on writing table
	c. Defective pen tip	c. Lap pen (Para. 4.8)
8. Pen will not travel on time line	a. Improper pen alignment	a. Align pen (Para. 4.3)
	b. Loose pen	b. Align and tighten pen
9. Pen does not return to same spot	a. Loose pen	a. Align and tighten pen
	b. Recorder out of calibration	b. Calibrate recorder (Sec. V)

MALFUNCTION	CAUSE	REMEDY
10. Pen does not move with input signal applied (all chart drive functions operate)	a. Improper input connections	a. Check input connections
	b. Defective preamplifier	b. Replace and/or repair
	c. Defective drive amplifier and power supply assembly	c. Replace and/or repair
	d. Defective cabling, and/or connections	d. Replace and/or repair

Section VIII
Parts Identification

8.1 GENERAL

This section contains reference view of the Mark 220 Recorder and electrical parts lists of the major assemblies in the recorder. Parts are listed in alpha-numeric sequence according to electronic symbol number. When ordering replacement parts, use the number listed in the PART NUMBER column, not the SYMBOL NUMBER.

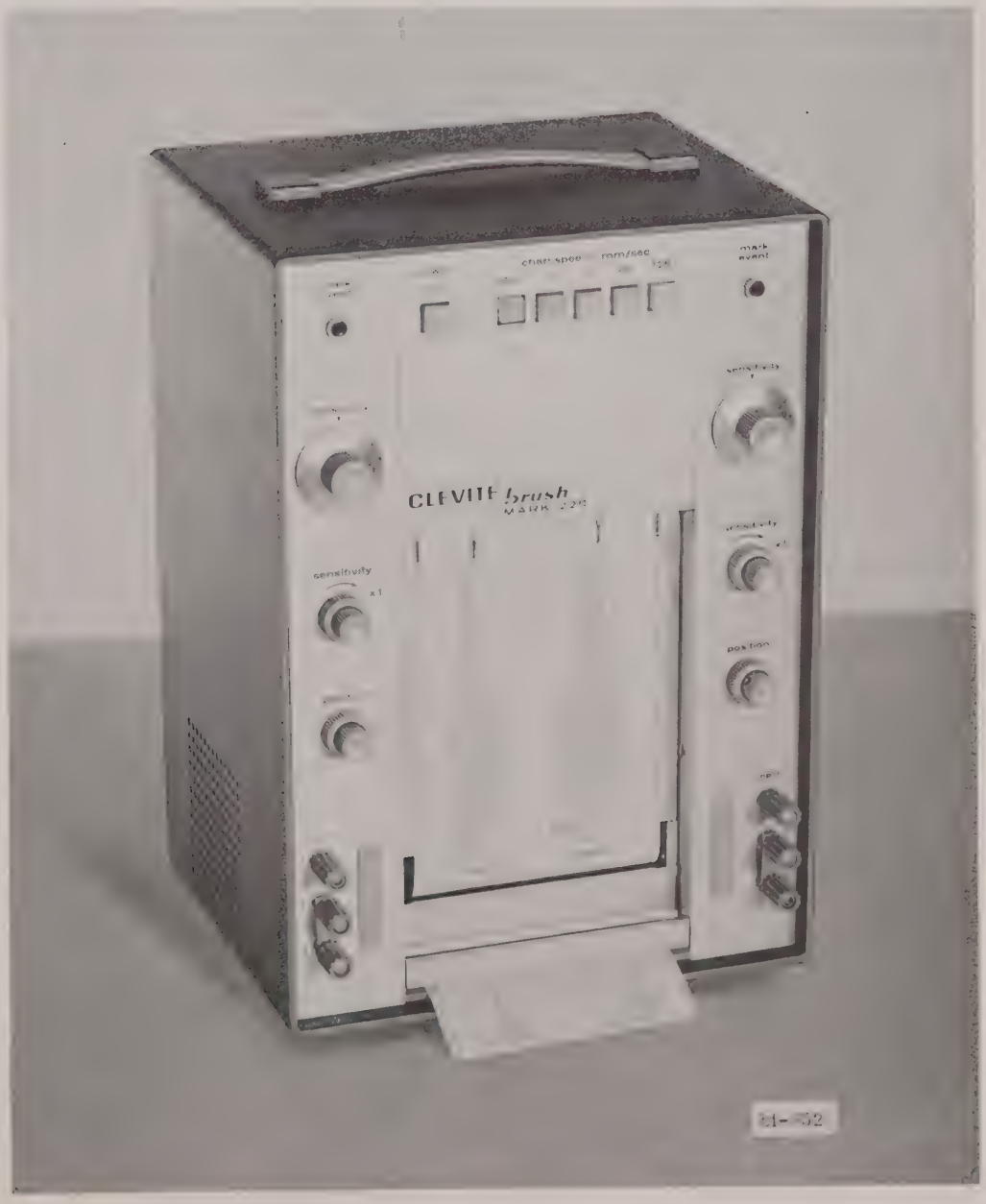


Figure 8-1 Mark 220 Recorder - Front View

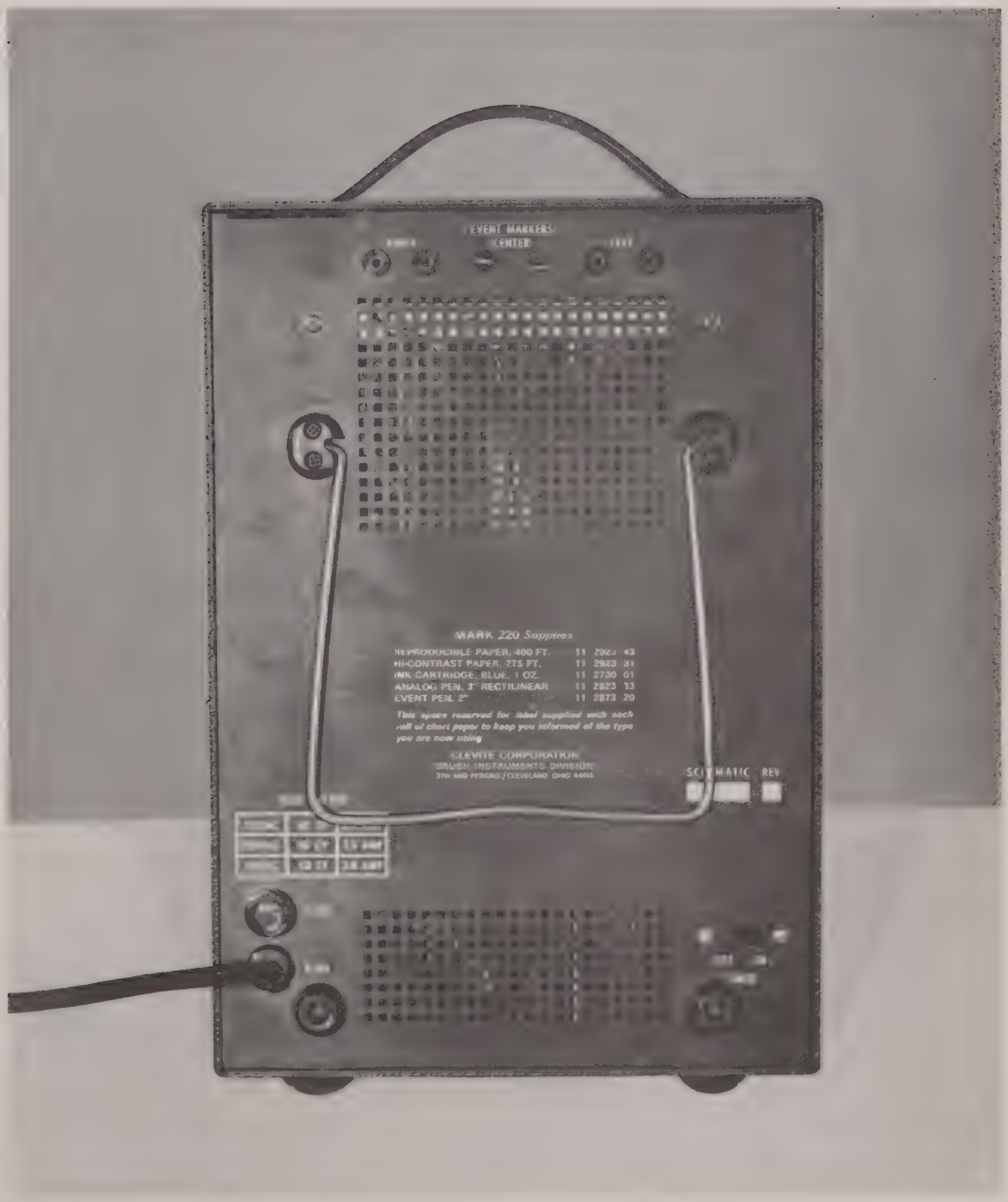

EVENT MARKERS
CENTER
MARK 220 Supplies
REPRODUCIBLE PAPER, 400 FT. 11 2923 43
HI-CONTRAST PAPER, 275 FT. 11 2923 31
INK CARTRIDGE, BLUE, 1 OZ. 11 2730 01
ANALOG PEN, 3" RECTILINEAR 11 2823 33
EVENT PEN, 2" 11 2873 20
This space reserved for label supplied with each roll of chart paper to keep you informed of the type you are now using
CLEVITE CORPORATION
BRUSH INSTRUMENTS DIVISION
37th AND PERKINS / CLEVELAND OHIO 44114
SCHEMATIC REV

Figure 8-2 Mark 220 Recorder - Rear View

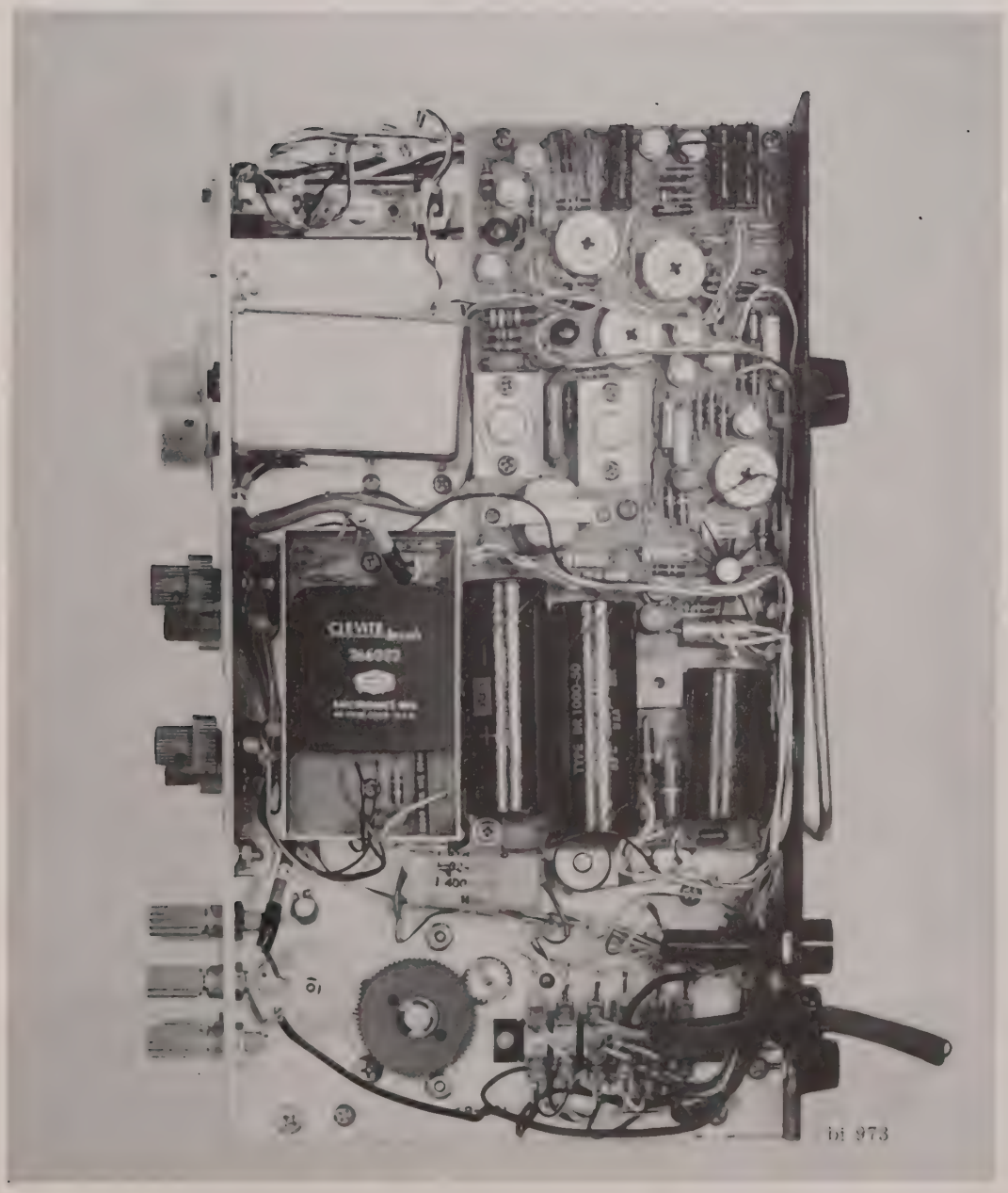


Figure 8-3 Mark 220 Recorder - Right Side View

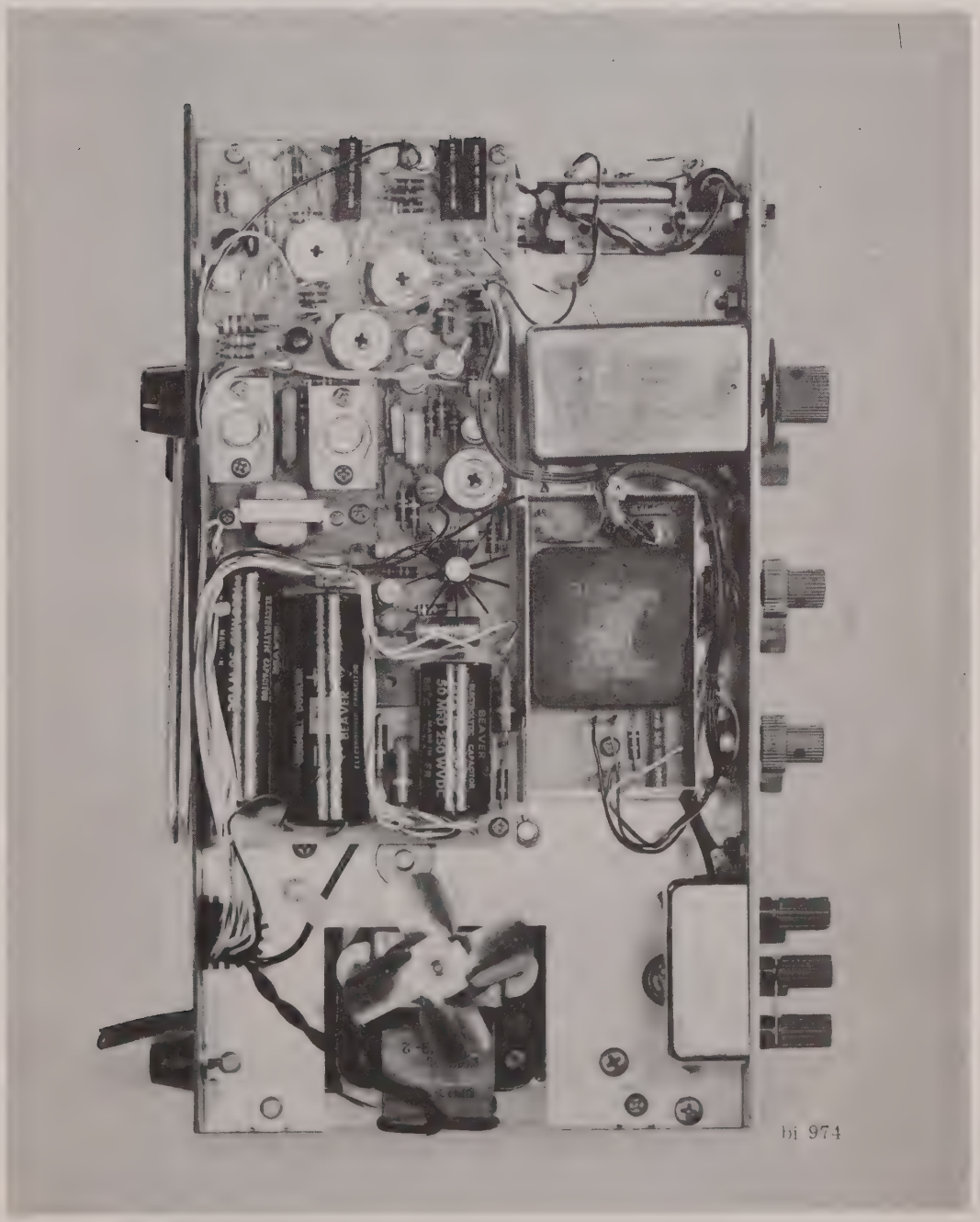


Figure 8-4 Mark 220 Recorder - Left Side View

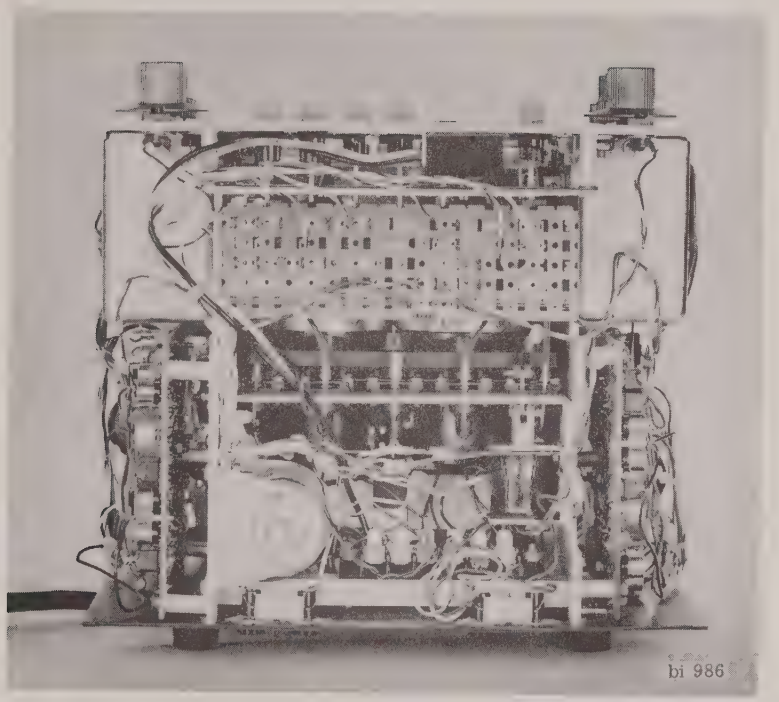


Figure 8-5 Mark 220 Recorder - Top View

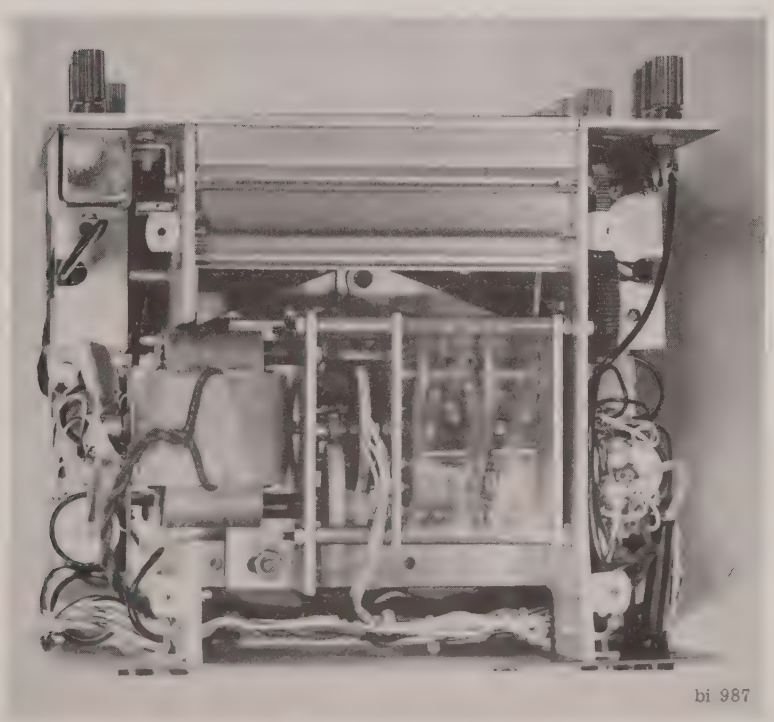


Figure 8-6 Mark 220 Recorder - Bottom View

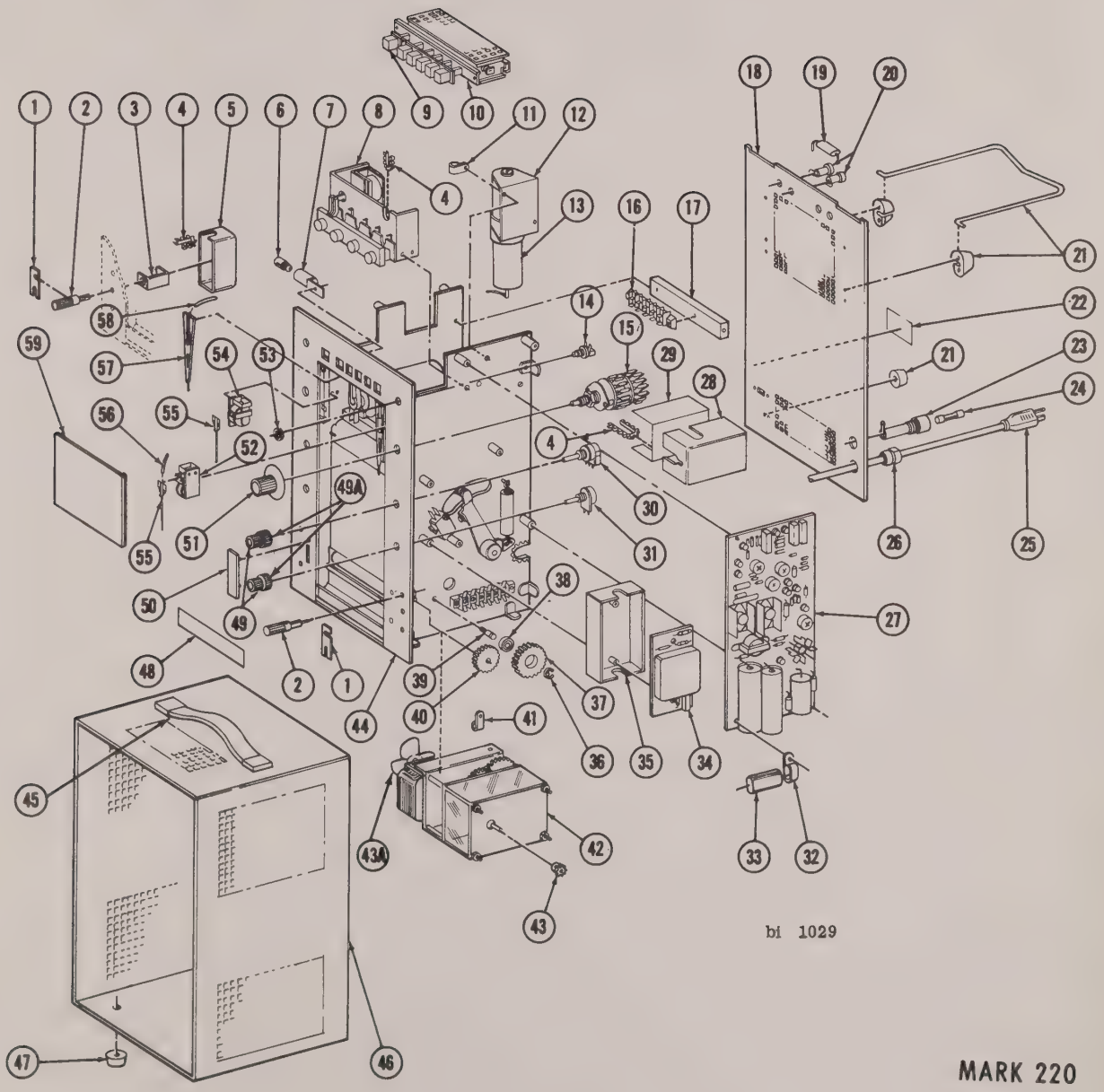
EXPLODED VIEW PARTS LIST
MARK 220 - ALL MODELS - FIGURE 8-7

ITEM NO.	PART NUMBER	DESCRIPTION	SYMBOL NO.
1	127457	Strap, Ground	
2	126395-13	Post, Binding	J-301,302,303
3	266558	Bracket	
4	2-218693-1	Grommet	
5	266494	Box Metallic	
6	128327	Lamp	DS-301
7	266063	Lampholder	
8	869022	Manifold Asm (see Fig. 8-10)	
9	246552-1	Button	
10	264930	Switch, Pushbutton	S-301
11	232660-4	Clamp	
12	766243	Ink Plunger Asm	
13	11-2730-01	Ink Cartridge Asm	
14	246422-1	Switch	S-305,306
15	865977*	Switch Asm, Attenuator (see Fig. 8-13)	S-101
15	767881	Switch Asm, Attn. (Preferred alternate)	S-101
16	265814-6	Terminal Board	TB-302
17	265860	Bar, Support	
18	866211	Cover Asm, Silkscreen	
19	10-241145-224	Capacitor	C-301,302
20	265873-2	Jack, Banana	J-304,305,306,307
21	266107-5	Bail	
22	465913-5	Plate, Identification (-50 only)	
22	465913-6	Plate, Identification (-55 only)	
22	465913-7	Plate, Identification (-56 only)	
23	109669	Holder, Fuse	
24	116198-13	Fuse (-50,-55 only)	F-301
24	266924-1	Fuse (-56 only)	F-301
25	126295-7	Cable Connector	P-301
26	108572-11	Strain Relief	
27	865818	Network Asm, Drive Amp (see Fig. 8-11)	
28	267454	Cover	
29	667453	Insulator	
30	246393-202	Resistor, Variable	R-301/S-302

* Use preferred alternate, Brush number 767881.

EXPLODED VIEW PARTS LIST (Continued)
MARK 220 - ALL MODELS - FIGURE 8-7

ITEM NO.	PART NUMBER	DESCRIPTION	SYMBOL NO.
31	246394-502	Resistor, Variable	R-302
32	124804-5	Clamp (-50 only)	
32	124804-7	Clamp (-55,-56 only)	
33	10-261998-824	Capacitor (-50 only)	C-303
33	10-125905-105	Capacitor (-55,-56 only)	C-303
34	766409	Network Asm, Preamplifier (see Fig. 8-12)	
35	666614	Shield Asm	
36	2-240731-11	Ring, Retaining	
37	243515	Gear, Spur Idler	
38	232250-2	Bearing, Roller, Needle	
39	266873	Post	
40	265906-2	Gear, Spur (-50 only)	
40	265906-1	Gear, Spur (-55,-56 only)	
41	232660-3	Clamp	
42	865917	Motor/Transmission Asm (-50 only)	
42	866706	Motor/Transmission Asm (-55,-56 only)	
43	265836	Gear, Spur 25T	
43A	266412-1	Fan	
44	866000	Recorder Subassembly (see Fig. 8-8)	
45	266209-4	Handle	
46	466007	Case	
47	120903-214	Bumper	
48	266823	Label, Channel I.D.	
49	231183	Knob	
49A	231182	Nut, Locking	
50	246388	Cover, Panel	
51	665563	Knob Asm	
52	11-2123-31	Event Marker Asm, L.H.	
53	246415	Nut, Plain, Knurled	
54	11-2123-32	Event Marker Asm, R.H.	
55	11-2873-20	Pen Asm, Ink	
56	666587	Tubing, Event	
57	11-2823-33	Pen Asm, Analog	
58	667277	Tubing Analog	
59	665796	Cover Asm, Silkscreen	



MARK 220
FIG. 8-7

EXPLODED VIEW PARTS LIST
MARK 220 - ALL MODELS - FIGURE 8-8

ITEM NO.	PART NUMBER	DESCRIPTION	SYMBOL NO.
1	865855	Plate Asm, L.H.	
2	31-119922-2602	Screw	
3	11305-37	Washer	
4	31-241908-0002	Screw	
5	241227	Washer	
6	241231-910	Band Asm	
7	Not Used		
8	332693-910	Drive Arm, Bracket	
9	31-121166-6202	Set Screw	
10	Not Used		
11	864750	Penmotor Asm (includes items 2, 3, 4, 5, 6, 8, and 9)	
12	266413-1*	Washer, Compression	
13	266871	Shield	
14	365506	Bar, Mounting Penmotor	
15	265542	Transformer	T-301
16	265975	Shaft, Straight	
17	743915-10	Arm Asm, Sensor	
18	243611-910	Lever Asm	
19	865715	Panel Asm, Front, Silkscreen	
20	243623	Spring Positioning	
21	243622	Pad, Friction	
22	665789	Lever Asm, R.H.	
23	365792	Catch, Cover	
24	865852	Plate Asm, R.H.	
25	2-128693-3	Grommet, Caterpillar	
26	643919-10	Disc Asm, Friction	
27	1-264521-2	Spring, Compression	
28	0-108400-15	Insulation, Sleeve	
29	1-130327-8	Insulation	
30	1-240031-3	Spring, Helical	
31	1-118195-304	Washer, Plain	
32	743913-10	Arm Subasm, Brake	
33	31-119924-6208	Screw Hex Head	
34	265814-6	Terminal Board	TB-301
35	1-265849-4	Bracket, Angle	

EXPLODED VIEW PARTS LIST (Continued)
MARK 220 - ALL MODELS - FIGURE 8-8

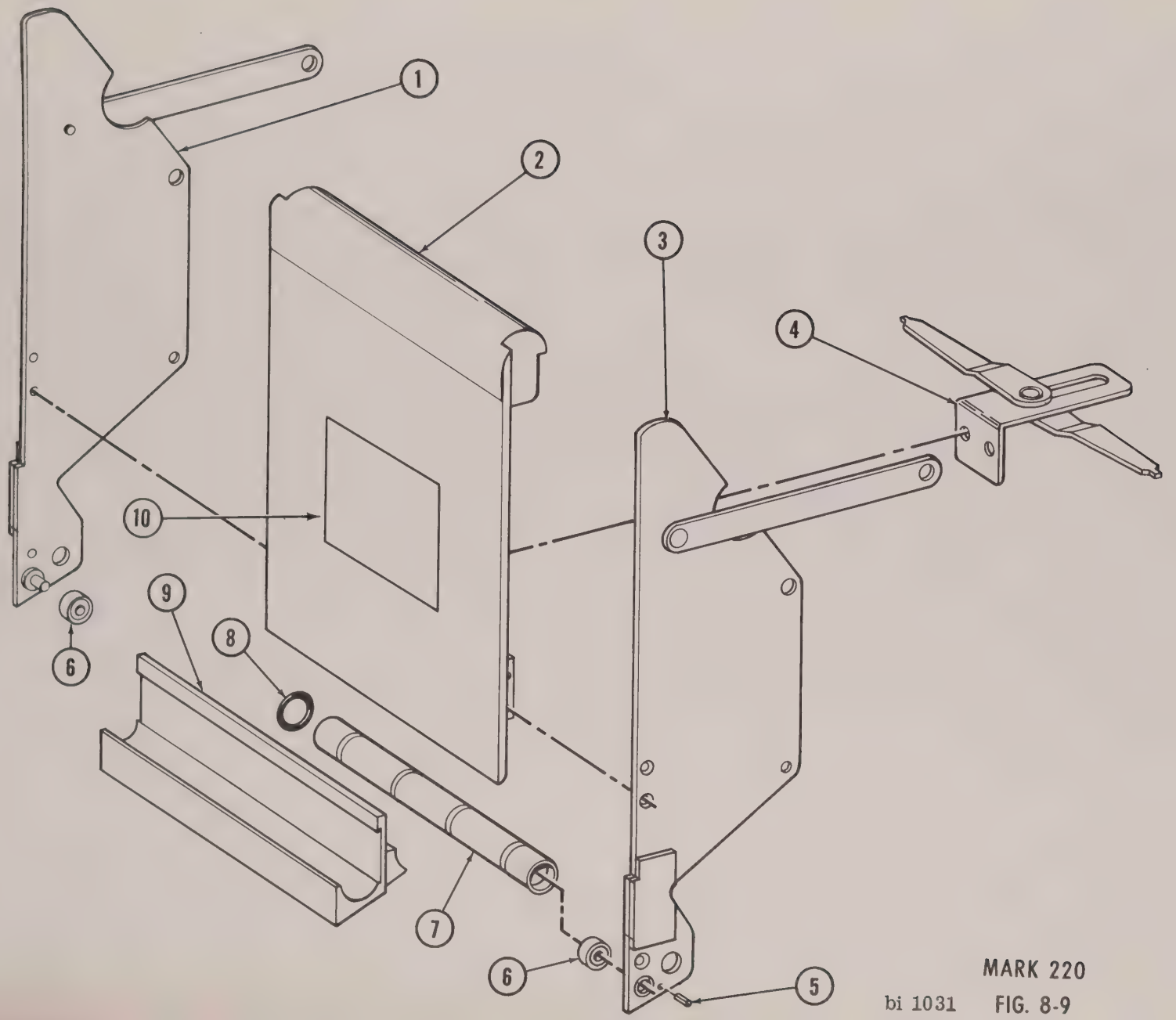
ITEM NO.	PART NUMBER	DESCRIPTION	SYMBOL NO.
36	267351-3	Bearing	
37	266326	Switch, Sensitive	S-304
38	665593	Roll, Drive	
39	765507	Chute, Paper	
40	266014	Deflector, Paper	
41	865596	Table Asm, Writing (see Fig. 8-9)	
42	666456	Supply Roll Asm	
43	265860	Bar, Support	
44	243440*	Bumper	
45	1-227070-9	Ring, Retaining	
46	243856-1*	Nut, Push-on	

*Not required on some models

MARK 220
FIG. 8-8

EXPLODED VIEW PARTS LIST
MARK 220 - ALL MODELS - FIGURE 8-9
TABLE ASM, WRITING - 865596

ITEM NO.	PART NUMBER	DESCRIPTION
1	343617-910	Support Asm, Left
2	765585	Bar Asm, Writing
3	343616-910	Support Asm, Right
4	765591	Paper Release Asm
5	4-112468-9	Pin, Spring
6	267351-1	Bearing
7	265534	Roll, Pressure
8	243867-1	Packing, Preformed
9	665854	Bar Asm, Pull
10	466842-1	Label



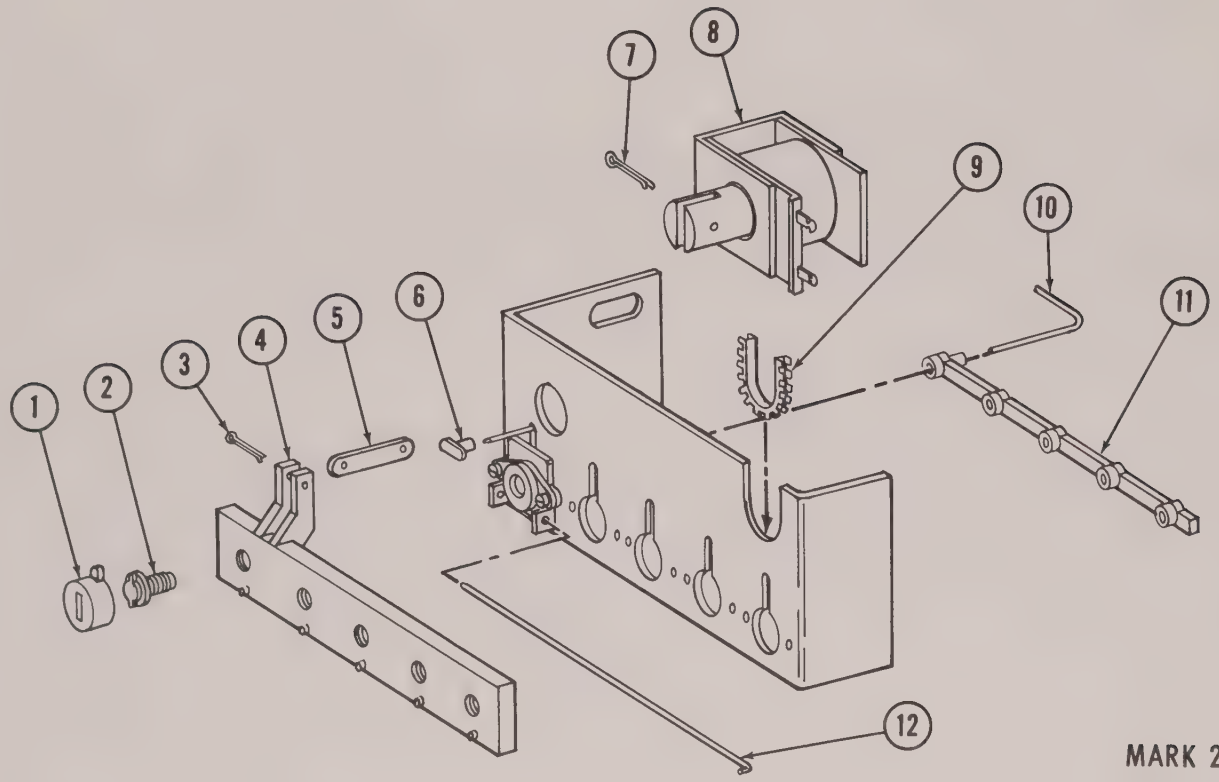
MARK 220

bi 1031 FIG. 8-9

EXPLODED VIEW PARTS LIST
MARK 220 - ALL MODELS - FIGURE 8-10
MANIFOLD ASM - 869022

ITEM NO	PART NUMBER	DESCRIPTION	SYMBOL NO
1	467355-1	Knob, Ink Control	
2	467355-5	Screw, Operator	
3	236865-2	Cotter Pin	
4	365991	Lever, Operator	
5	265990	Link, Connecting	
6	249360	Cap, Ink Outlet	
7	236865-3	Cotter Pin	
8	266888	Solenoid	L-301
9	2-218693-3	Grommet	
10	666582	Tube	
11	367081	Supply, Manifold	
12	265989	Shaft	

NOTE: All remaining manifold parts are non-repairable items. Therefore, part numbers are not listed.



MARK 220

bi 1032 FIG. 8-10

ELECTRICAL PARTS LIST - FIGURE 8-11
AMPLIFIER & POWER SUPPLY NETWORK ASSEMBLY 865818

SYMBOL NO.	PART NUMBER	DESCRIPTION
C-201	10-231854-271	Capacitor
C-202	243037-108	Capacitor
C-203	243037-108	Capacitor
C-204	10-125904-602	Capacitor
C-205	10-125904-602	Capacitor
C-206	243006-356	Capacitor
C-207	10-241145-503	Capacitor
C-208	243006-505	Capacitor
C-209	10-241145-503	Capacitor
C-210	10-125904-203	Capacitor
C-211	241513-506	Capacitor
C-212	10-125904-303	Capacitor
CR-201	244311*	Semiconductor 1N277
CR-202	231869*	Semiconductor 1N816
CR-203	244311	Semiconductor 1N277
CR-204	244311	Semiconductor 1N277
CR-205	231869	Semiconductor 1N816
CR-206	244311	Semiconductor 1N277
CR-207	249747*	Semiconductor 1N752
CR-208	249747	Semiconductor 1N752
CR-209	10-244922-8*	Semiconductor UZ818
CR-210	10-244922-8	Semiconductor UZ818
CR-211	244311	Semiconductor 1N277
CR-212	244311	Semiconductor 1N277
CR-213	231869	Semiconductor 1N816
CR-214	231869	Semiconductor 1N816
CR-215	265420-1*	Semiconductor
CR-216	244311	Semiconductor 1N277
CR-217	130198-3	Semiconductor 1N2071
L-201	263453-1	Reactor
L-202	263453-1	Reactor
L-203	243179	Reactor

*Recommended spare for 2000-hour operation

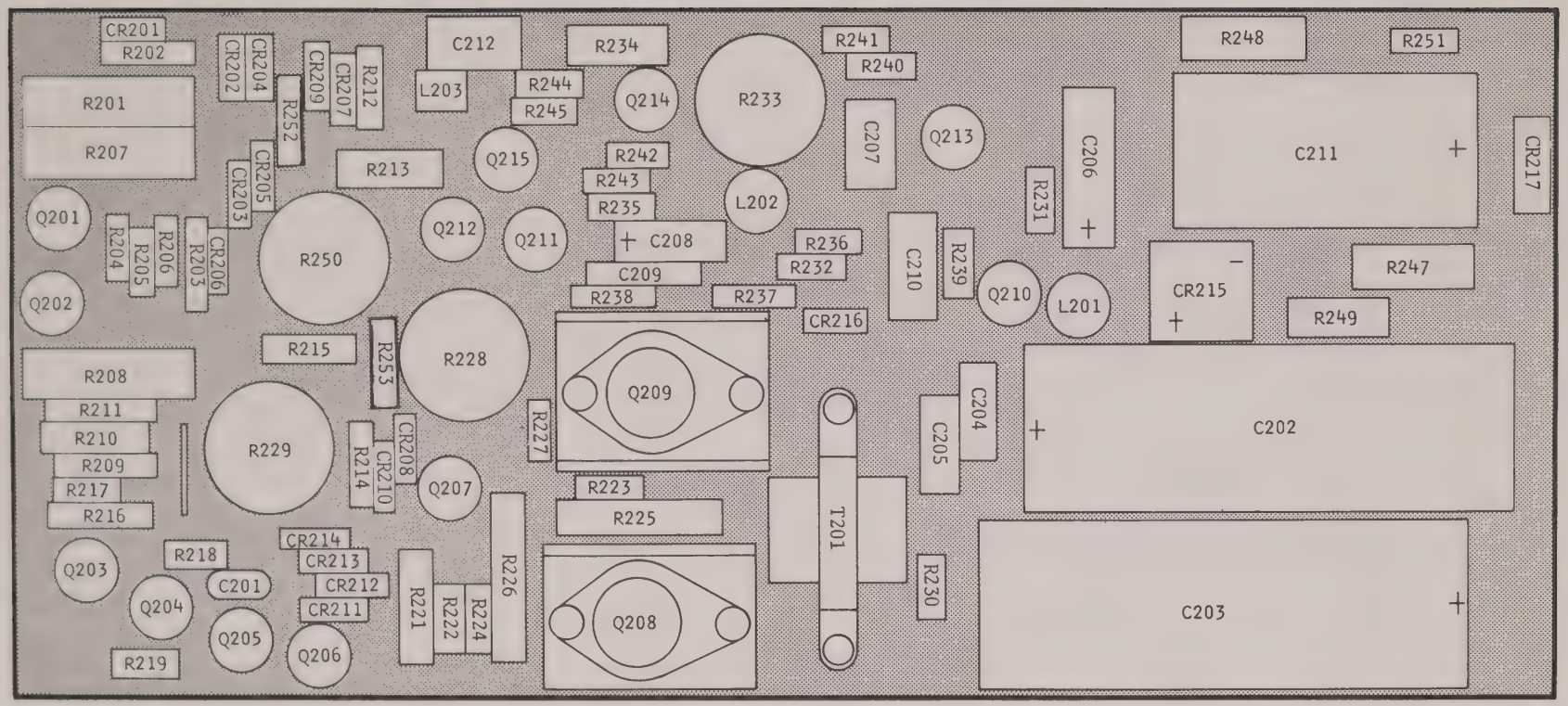
ELECTRICAL PARTS LIST - FIGURE 8-11 (Continued)
AMPLIFIER & POWER SUPPLY NETWORK ASSEMBLY 865818

SYMBOL NO.	PART NUMBER	DESCRIPTION
Q-201	242323*	Transistor
Q-202	242323	Transistor
Q-203	242323	Transistor
Q-204	242323	Transistor
Q-205	263901*	Transistor 2N3645
Q-206	242323	Transistor
Q-207	263901	Transistor 2N3645
Q-208	262804*	Transistor 40312
Q-209	262804	Transistor 40312
Q-210	242323	Transistor
Q-211	242323	Transistor
Q-212	242323	Transistor
Q-213	242323	Transistor
Q-214	240237*	Transistor 2N1302
Q-215	240236*	Transistor 2N1303
R-201	244771-103	Resistor, Variable
R-202	1-128182-91671	Resistor
R-203	1-128182-1103	Resistor
R-204	5-115557-822	Resistor
R-205	5-115557-122	Resistor
R-206	5-115557-472	Resistor
R-207	244771-502	Resistor, Variable
R-208	244771-502	Resistor, Variable
R-209	1-128182-2003	Resistor
R-210	1-128182-1503	Resistor
R-211	1-128182-7502	Resistor
R-212	5-115557-102	Resistor
R-213	5-115558-331	Resistor
R-214	5-115557-102	Resistor
R-215	1-128182-1003	Resistor
R-216	1-128182-7502	Resistor
R-217	5-115557-125	Resistor
R-218	5-115557-473	Resistor

*Recommended spare for 2000-hour operation

ELECTRICAL PARTS LIST - FIGURE 8-11 (Continued)
AMPLIFIER & POWER SUPPLY NETWORK ASSEMBLY 865818

SYMBOL NO.	PART NUMBER	DESCRIPTION
R-221	5-115558-331	Resistor
R-222	5-115557-273	Resistor
R-223	5-115557-561	Resistor
R-224	5-115557-561	Resistor
R-225	5-119370-5R0	Resistor
R-226	5-119370-5R0	Resistor
R-227	5-115557-273	Resistor
R-228	248813-502	Resistor, Variable
R-229	248813-103	Resistor, Variable
R-230	5-115557-102	Resistor
R-231	5-115557-393	Resistor
R-232	5-115557-153	Resistor
R-233	248813-502	Resistor, Variable
R-234	1-128182-3601	Resistor
R-235	5-115557-272	Resistor
R-236	5-115557-392	Resistor
R-237	1-128182-1002	Resistor
R-238	1-128182-3601	Resistor
R-239	5-115557-823	Resistor
R-240	5-115557-223	Resistor
R-241	5-115557-151	Resistor
R-242	5-115557-103	Resistor
R-243	5-115557-103	Resistor
R-244	5-115557-153	Resistor
R-245	5-115557-153	Resistor
R-247	5-115559-152	Resistor
R-248	5-115559-152	Resistor
R-249	5-115558-222	Resistor
R-250	248813-502	Resistor, Variable
R-251	5-115558-220	Resistor
R-252	5-115557-472	Resistor
R-253	1-128182-6801	Resistor
T-201	263516	Transformer



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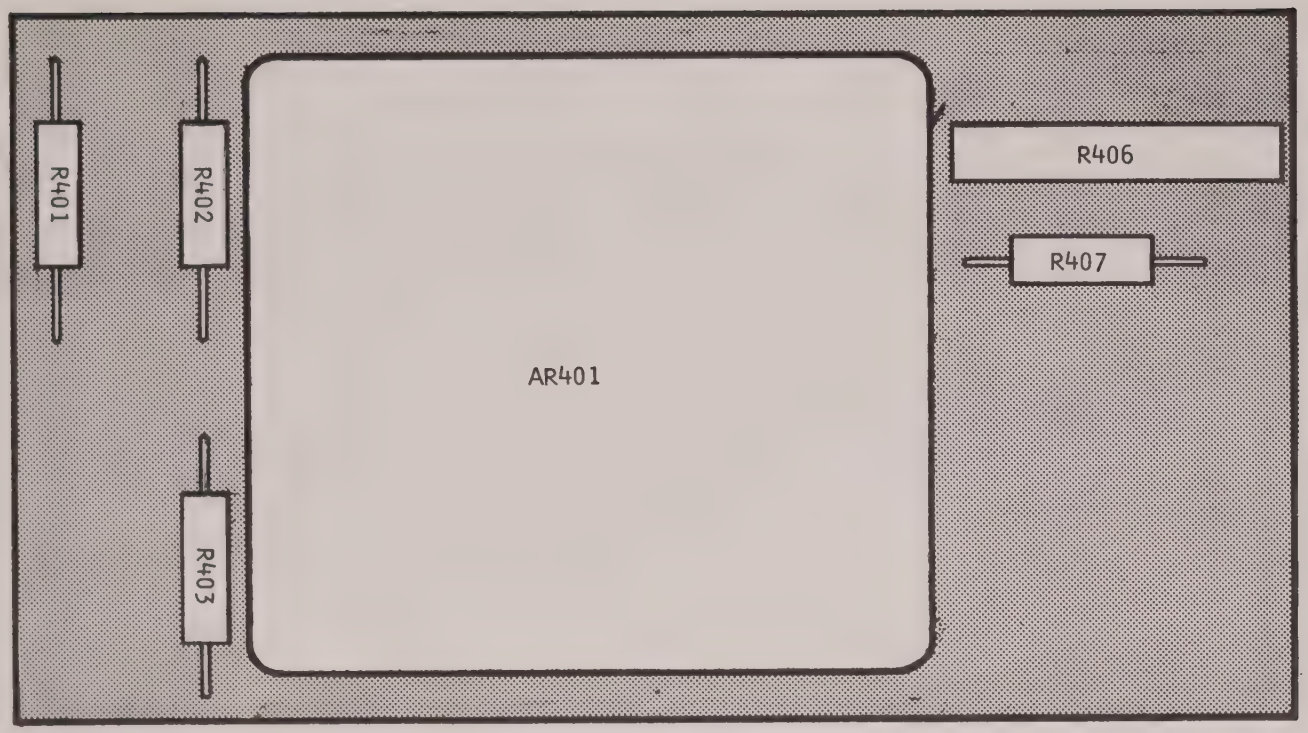
AMPLIFIER & POWER SUPPLIES
NETWORK ASSEMBLY
865818

ELECTRICAL PARTS LIST - FIGURE 8-12
PREAMPLIFIER ASSEMBLY 766409

SYMBOL NO.	PART NUMBER	DESCRIPTION
AR-401	266002	Transducer Amplifier
R-401	1-117802-5003	Resistor
R-402	1-117802-5003	Resistor
R-403	1-128182-1001	Resistor
R-406	266337-503	Resistor, Variable
R-407	5-115557-331	Resistor



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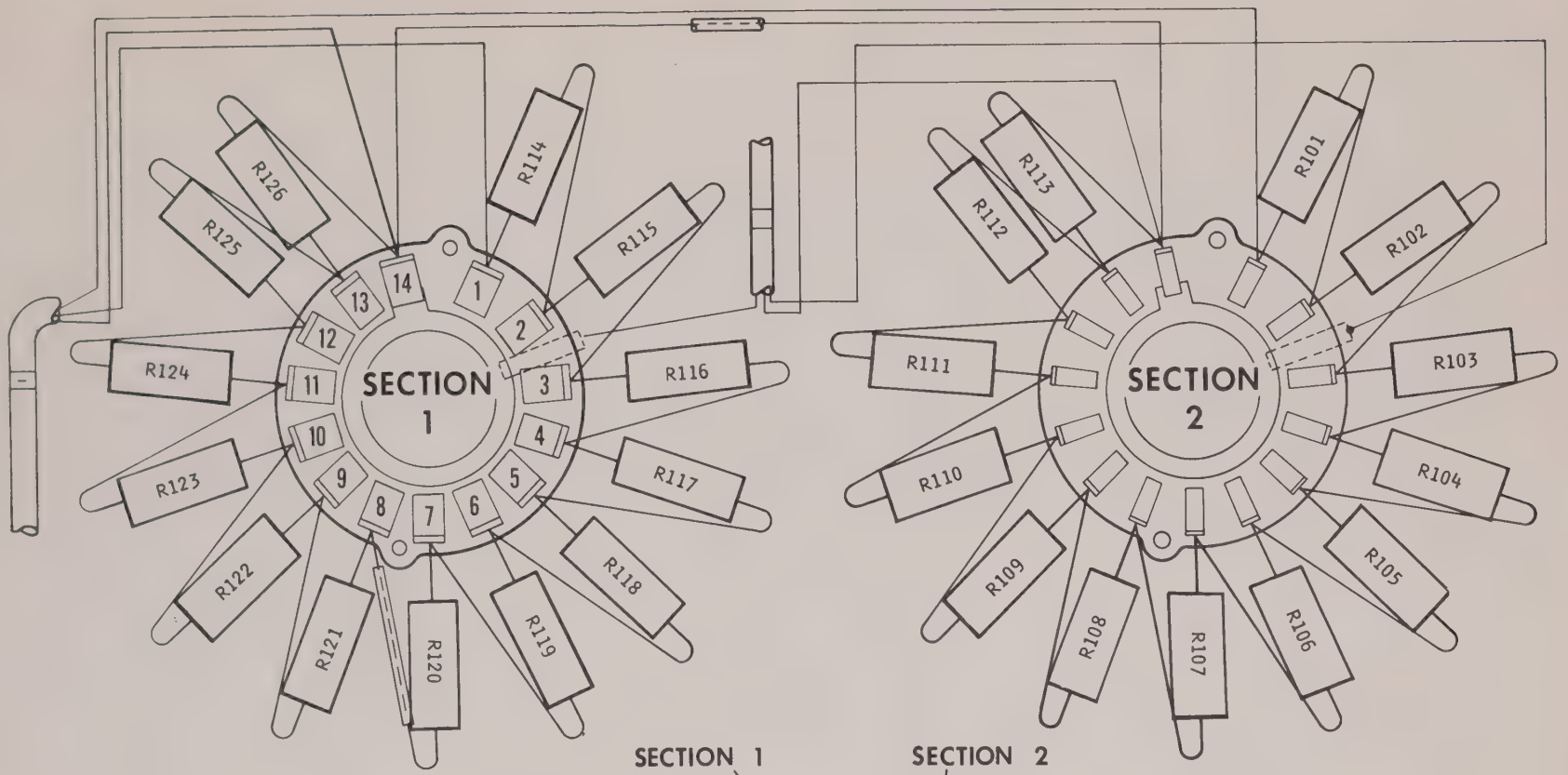
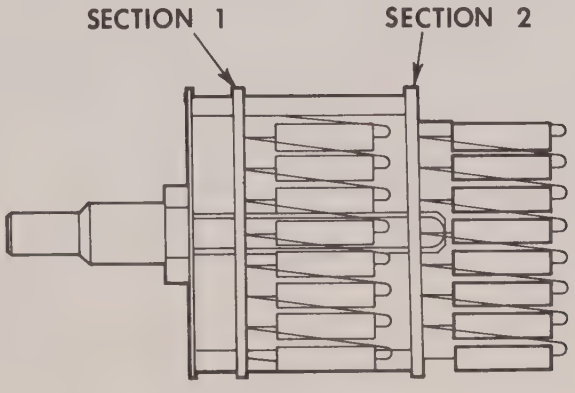
PREAMPLIFIER ASSEMBLY
FIG. 8-12

ELECTRICAL PARTS LIST - FIGURE 8-13
SWITCH ASSEMBLY - 865977

SYMBOL NO.	PART NUMBER	DESCRIPTION
R-101	50-128182-2504	Resistor
R-102	50-128182-1504	Resistor
R-103	50-128182-5003	Resistor
R-104	50-128182-2503	Resistor
R-105	50-128182-1503	Resistor
R-106	50-128182-5002	Resistor
R-107	50-128182-2502	Resistor
R-108	50-128182-1502	Resistor
R-109	50-128182-5001	Resistor
R-110	50-128182-2501	Resistor
R-111	50-128182-1501	Resistor
R-112	50-128182-5000	Resistor
R-113	50-128182-5000	Resistor
R-114	50-128182-2504	Resistor
R-115	50-128182-1504	Resistor
R-116	50-128182-5003	Resistor
R-117	50-128182-2503	Resistor
R-118	50-128182-1503	Resistor
R-119	50-128182-5002	Resistor
R-120	50-128182-2502	Resistor
R-121	50-128182-1502	Resistor
R-122	50-128182-5001	Resistor
R-123	50-128182-2501	Resistor
R-124	50-128182-1501	Resistor
R-125	50-128182-5000	Resistor
R-126	50-128182-5000	Resistor
S-101	265504	Switch





SIDE VIEW

bi 1034

SWITCH ASSEMBLY
FIG. 8-13

EXPLODED VIEW PARTS LIST
MARK 220 - ALL MODELS - FIGURE 8-14
CHART TAKEUP ASM - 11-6402-03

ITEM NO.	PART NUMBER	DESCRIPTION
1	249618-1	Plate Cover, Left
2	243867-5	"O" Ring
3	267257	Pulley
4	243696	Retainer, Bearing
5	1-210761-1	Bearing
6	246651	Roller, Guide
7	246307	Block
8	767254-3	Arm Asm, L.H.
9	3-249640-8206	Screw, Flat Head
10	666123	Shaft Asm (includes Bearing part No. 1-210761-1)
11	767249-3	Arm Asm, R.H.
12	249617-1	Plate Cover, Left
13	267253	Spring Compression
14	266184	Shaft, Shouldered
15	243740	Collar
16	4-112468-14	Pin, Roll
17	266053	Shaft

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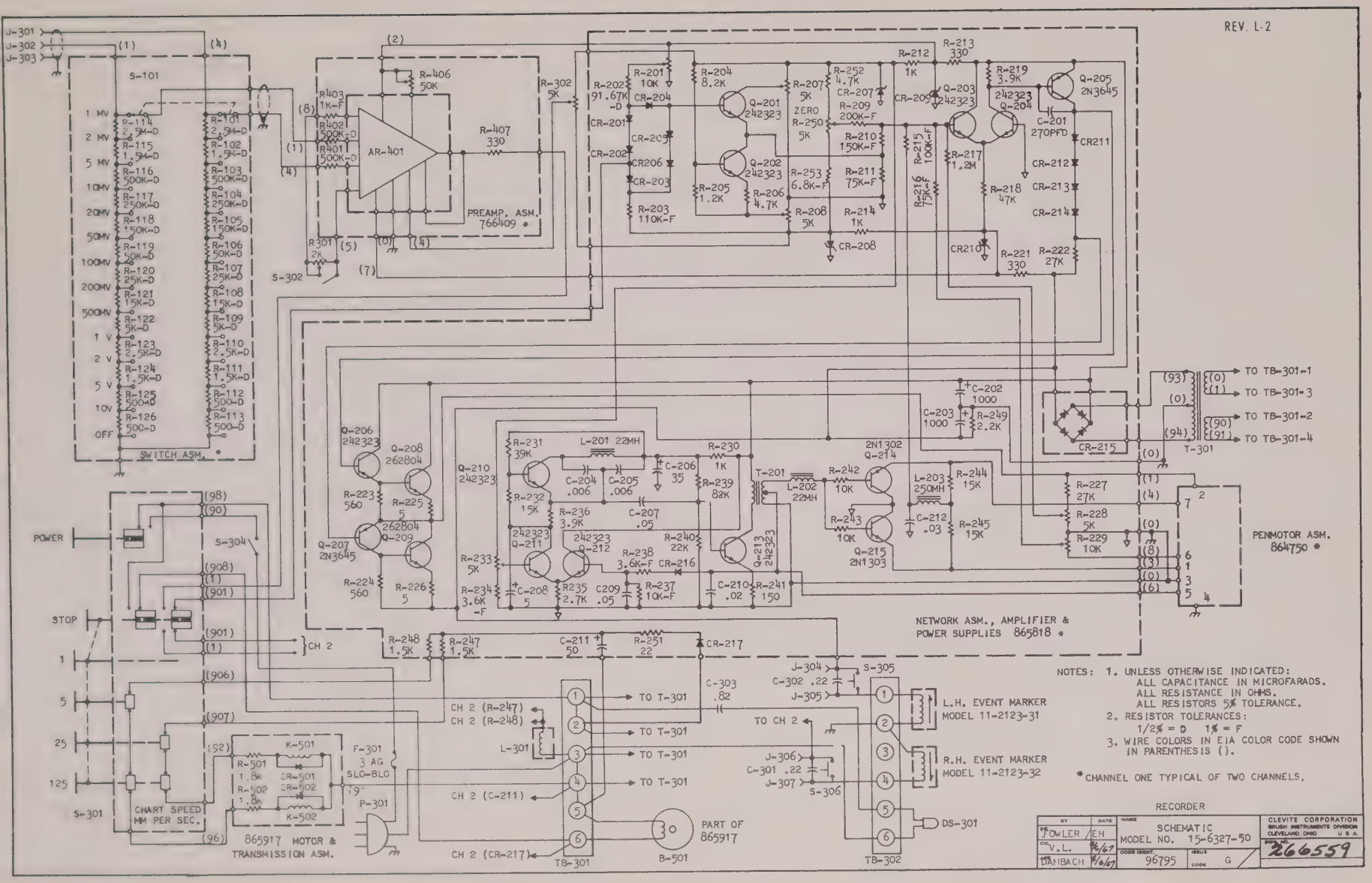
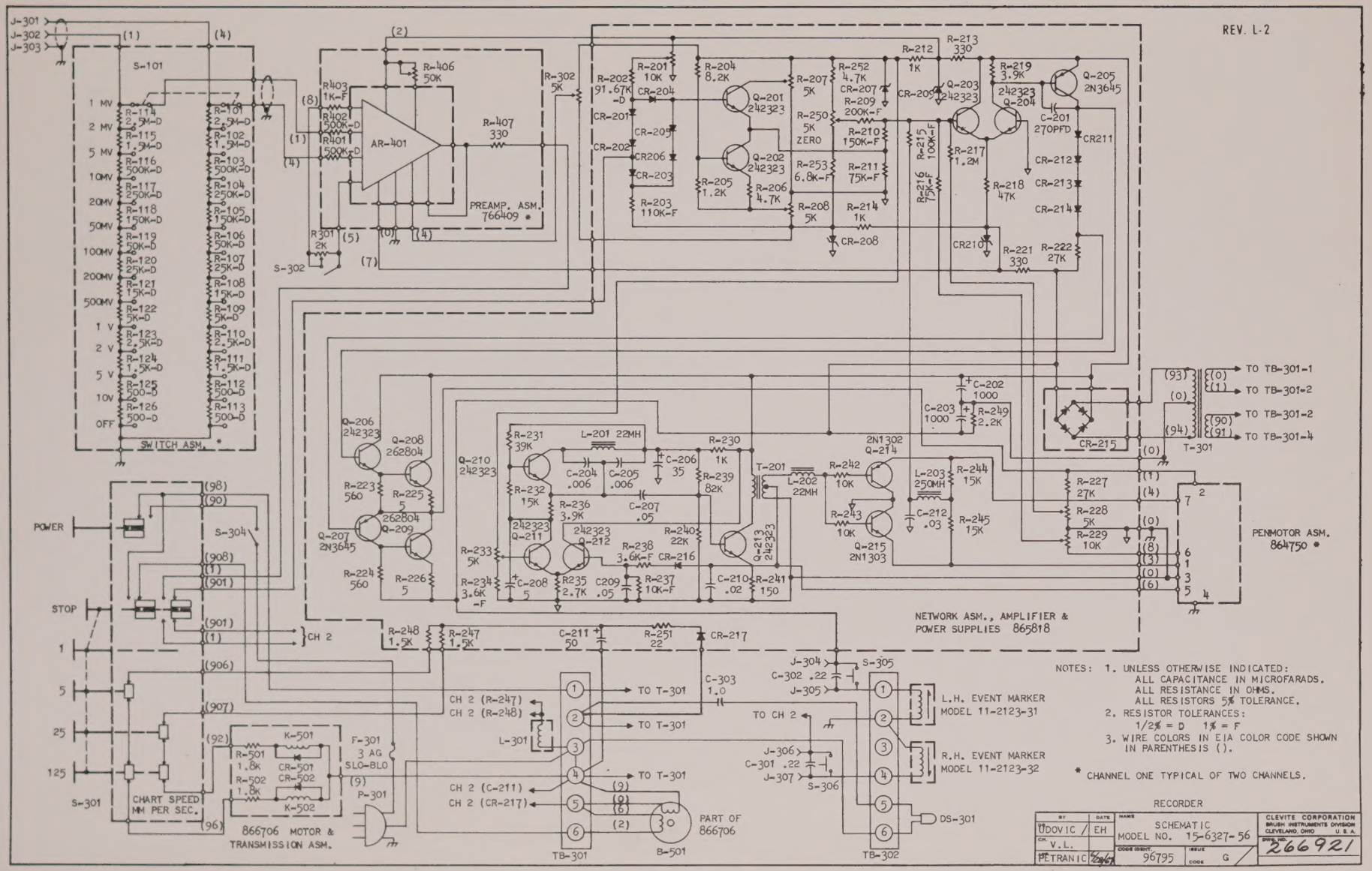
CHART TAKE-UP
FIG. 8-14


REV. L-2
J-301
J-302
J-303
S-101
SWITCH ASM. *
PREAMP. ASM. 766409 *
AR-401
S-302
S-304
POWER
STOP
CH 2
S-301
CHART SPEED MM PER SEC.
865917 MOTOR & TRANSMISSION ASM.
NETWORK ASM., AMPLIFIER & POWER SUPPLIES 865818 *
PENMOTOR ASM. 864750 *
T-301
CR-215
TO TB-301-1
TO TB-301-3
TO TB-301-2
TO TB-301-4
L-201 22MH
L-202 22MH
L-203 250MH
T-201
L-301
F-301 3 AG SLO-BLO
P-301
B-501
PART OF 865917
TB-301
TB-302
S-305
S-306
L.H. EVENT MARKER MODEL 11-2123-31
R.H. EVENT MARKER MODEL 11-2123-32
DS-301
TO T-301
TO CH 2
CH 2 (R-247)
CH 2 (R-248)
CH 2 (C-211)
CH 2 (CR-217)
NOTES: 1. UNLESS OTHERWISE INDICATED:
ALL CAPACITANCE IN MICROFARADS.
ALL RESISTANCE IN OHMS.
ALL RESISTORS 5% TOLERANCE.
2. RESISTOR TOLERANCES:
1/2% = D 1% = F
3. WIRE COLORS IN EIA COLOR CODE SHOWN IN PARENTHESIS ().
*CHANNEL ONE TYPICAL OF TWO CHANNELS.
RECORDER
SCHEMATIC
MODEL NO. 15-6327-50
CLEVITE CORPORATION
BRUSH INSTRUMENTS DIVISION
CLEVELAND, OHIO U.S.A.
FOWLER EH
V.L. 11/6/67
DAMBACH 11/6/67
96795
G
266559


REV. L-2
J-301
J-302
J-303
S-101
SWITCH ASM.
1 MV
2 MV
5 MV
10MV
20MV
50MV
100MV
200MV
500MV
1 V
2 V
5 V
10V
OFF
PREAMP. ASM. 766409 *
AR-401
S-302
R-406 50K
R-407 330
R-302 5K
R403 1K-F
R402 500K-D
R401 500K-D
R301 2K
NETWORK ASM., AMPLIFIER & POWER SUPPLIES 865818
Q-201 242323
Q-202 242323
Q-203 242323
Q-204 242323
Q-205 2N3645
Q-206 242323
Q-207 2N3645
Q-208 262804
Q-209 262804
Q-210 242323
Q-211 242323
Q-212 242323
Q-213 242323
Q-214 2N1302
Q-215 2N1303
CR-208
CR-215
CR-216
CR-217
T-201
T-301
L-201 22MH
L-202 22MH
L-203 250MH
L-301
TO TB-301-1
TO TB-301-2
TO TB-301-2
TO TB-301-4
PENMOTOR ASM. 864750 *
POWER
STOP
S-304
CH 2
S-301
CHART SPEED MM PER SEC.
1
5
25
125
866706 MOTOR & TRANSMISSION ASM.
K-501
K-502
CR-501
CR-502
R-501 1.8K
R-502 1.8K
F-301 3 AG SLO-BLO
P-301
CH 2 (R-247)
CH 2 (R-248)
CH 2 (C-211)
CH 2 (CR-217)
TO T-301
TO CH 2
TB-301
TB-302
B-501
PART OF 866706
J-304
J-305
J-306
J-307
S-305
S-306
L.H. EVENT MARKER MODEL 11-2123-31
R.H. EVENT MARKER MODEL 11-2123-32
DS-301
NOTES: 1. UNLESS OTHERWISE INDICATED:
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1/2% = D 1% = F
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* CHANNEL ONE TYPICAL OF TWO CHANNELS.
RECORDER
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CORPORATION